TRAM® X51 Modules

Service Manual

2025936-001 Revision A

GE Medical Systems
Information Technologies

gemedical.com

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For your notes

1 Introduction

For your notes

Manual Information

Revision History

Each page of this document has the document part number and revision letter at the bottom of the page. The revision letter changes whenever the document is updated.

Revision	Comments
A	Initial release.

Purpose

This manual provides technical information for service representatives and technical personnel for maintaining the equipment to the assembly level.

Intended Audience

Users of this manual are expected to have a strong background in electronics, including analog and digital circuity with microprocessor and micro-controller architecture. It is intended for service representatives and technical personnel who maintain, troubleshoot, or repair this equipment.

Ordering Manuals

To order additional copies of this manual, call Accessories and Supplies and request part number 2025936-001 for a paper copy, and 2025937-001 for a CD ROM copy. Refer to the How To Reach Us page for Accessories and Supplies contact information.

Safety Information

Responsibility of the Manufacturer

GE Medical Systems *Information Technologies* is responsible for the effects of safety, reliability, and performance only if:

- assembly operations, extensions, readjustments, modifications, or repairs are carried out by persons authorized by GE Medical Systems *Information Technologies*.
- the electrical installation of the relevant room complies with the requirements of the appropriate regulations.
- the equipment is used in accordance with the instructions for use.

Intended Use

This device is intended for use under the direct supervision of a licensed health care practitioner.

This device is not intended for home use.

Federal law restricts this device to be sold by or on the order of a physician.

Contact GE Medical Systems *Information Technologies* for information before connecting any devices to the equipment that are not recommended in this manual.

Parts and accessories used must meet the requirements of the applicable IEC 60601 series safety standards, and/or the system configuration must meet the requirements of the IEC 60601 medical electrical systems standard.

Periodically, and whenever the integrity of the device is in doubt, test all functions.

The use of ACCESSORY equipment not complying with the equivalent safety requirements of this equipment may lead to a reduced level of safety of the resulting system. Consideration relating to the choice shall include:

- use of the accessory in the PATIENT VICINITY; and
- evidence that the safety certification of the ACCESSORY has been performed in accordance to the appropriate IEC 60601-1 and/or IEC 60601-1-1 harmonized national standard.

If the installation of the equipment, in the USA, will use 240V rather than 120V, the source must be a center-tapped, 240V, single-phase circuit.

Definitions Warnings, Cautions, and Notes

Warnings, cautions and notes are used throughout this manual to designate a degree or level or hazardous situations. Hazard is defined as a source of potential injury to a person.

DANGER
indicates an imminent hazard which, if not avoided, will result in death or serious injury.

WARNING
indicates an potential hazard or unsafe practice which, if not avoided, could result in death or serious injury.

CAUTION
indicates a potential hazard or unsafe practice which, if not avoided, could result in minor personal injury or product/property damage.

NOTE
provides application tips or other useful information to assure that you get the most from your equipment.

Equipment Symbols

The following symbols appear on the equipment.

ATTENTION: Consult accompanying documents before using the equipment.

Defibrillator-proof type CF equipment; type CF equipment is specifically designed for applications where a conductive connection directly to the heart is established. The paddles indicate the equipment is defibrillator proof.

Defibrillator-proof type BF equipment; type BF equipment is specifically designed for applications intentional external and internal application to the patient, excluding direct cardiac application. Type BF equipment is type B equipment with an F-type isolated (floating) part. The paddles indicate the equipment is defibrillator proof.

4P41

Medical Equipment
With respect to electric shock, fire and mechanical hazards only in accordance with UL 60601-1, CAN/CSA C22.2 NO. 601.1, IEC 60601-1, IEC 60601-2-27, IEC 60601-2-30, IEC 60601-2-34, and IEC 60601-2-49.

This symbol indicates that the waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer for information concerning the decommissioning of your equipment.

2005-08

This symbol indicates the date of manufacture of this device. The first four digits identify the year and the last two digits identify the month.

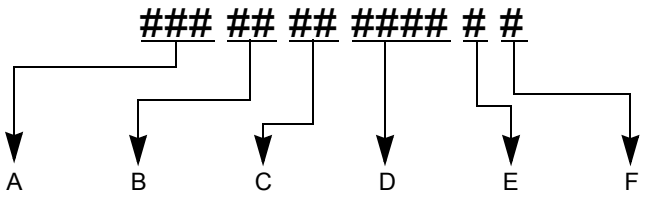
Service Information

Service Requirements

- Refer equipment servicing to GE Medical Systems *Information Technologies* authorized service personnel only.
- Any unauthorized attempt to repair equipment under warranty voids that warranty.
- It is the user's responsibility to report the need for service to GE Medical Systems *Information Technologies* or to one of their authorized agents.
- Failure on the part of the responsible individual, hospital, or institution using this equipment to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards.
- Regular maintenance, irrespective of usage, is essential to ensure the equipment will always be functional when required.

Equipment Identification

Every GE Medical Systems *Information Technologies* device has a unique serial number for identification. A sample of the information found on a serial number label is shown below.



	Description
A	product code
B	year manufactured
C	fiscal week manufactured
D	production sequence number
E	manufacturing site
F	miscellaneous characteristic

For your notes

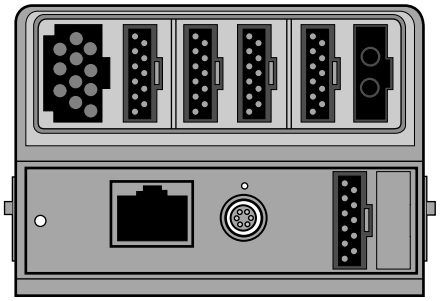
2 Equipment Overview

For your notes

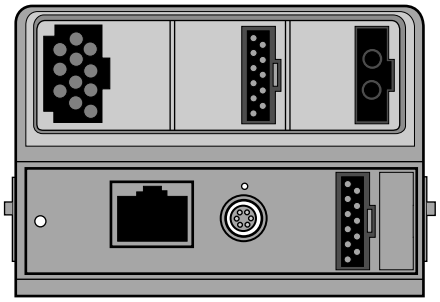
Module Identification

The illustrations below identify the various module assemblies visually by their connectors.

Tram 451, 451M, and 451N5 Modules



Tram 851, 851M and 851N5 Modules



System Components

Tram modules are plug-in/pull-out modules used in GE Medical Systems *Information Technologies* monitoring systems and transport displays. Modules collect data from a patient, convert the data to a digital form for processing and send the data to a bedside or surgical monitor, or a transport display for further processing and display. The data that a Tram module collects, converts, and sends includes the patient's vital signs and physiological waveforms.

The Tram module also stores a patient history including trends and special events, and setup information such as, blood pressure zero points and alarm limit settings. The patient history is stored so that the collected information is transferred when a patient is transferred to a different monitor.

Compatible Monitors

Tram modules work with Solar monitors, Tramscope monitors and Tram transport displays.

NOTE

Tram module software versions 11 and later are NOT compatible with the following products:

- Series 7000 patient monitors
- Series 7005 patient monitors
- Series 7010 patient monitors
- Series 7010RA patient monitors
- Series 8000 patient monitors
- Mac-Lab async modules

The type of Tram module determines what parameters it monitors. A label on the front of the module identifies the type of module.

Module Features

This table lists the vital signs monitored by each Tram X51 series module.

Tram Module	12-Lead ECG Analysis	Resp	Temp/CO	Dinamap NBP	Invasive BP	GE Ohmeda SpO2[†]	Masimo SpO_2	Nellcor OxiSmart SpO_2	Nellcor OxiMax SpO_2	Defib/ Sync[‡]
451	✓	✓	✓	✓	3/4[*]	✓				✓
451M	✓	✓	✓	✓	3/4[*]		✓			✓
451N	✓	✓	✓	✓	3/4[*]			✓		✓
451N5	✓	✓	✓	✓	3/4[*]				✓	✓
851	✓	✓	✓	✓		✓				✓
851M	✓	✓	✓	✓			✓			✓
851N5	✓	✓	✓	✓					✓	✓

[*] A dual BP adapter cable is required to monitor four invasive blood pressures.

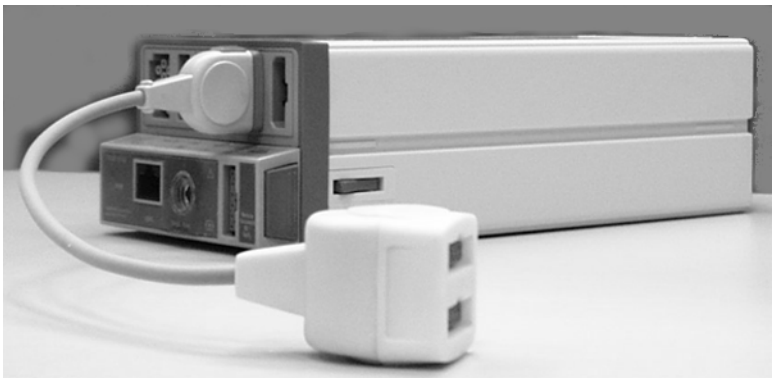
[‡] The Defib Sync connector on X51 series modules has a 7-pin connector that is DIFFERENT than the other Tram module series Defib Sync connectors. They are NOT interchangeable.

Compatible Adapter Cables/Sensors

Tram			Adapter Cable Part Number		
Model	Description	Conn Key	Nellcor RCAL OxiSmart	Nellcor Digical OxiMax	Masimo LNOP
T451N/851N	Nellcor OxiSmart	D	2006644-001	NA	NA
T451M/851M	Masimo Set	EF	NA	NA	2017002-001
T451/851	GE Ohmeda	D	2006644-001	NA	NA
T451N5/T851N5	Nellcor OxiMax	EF	NA	2021406-001	NA
			Compatible Sensors		
			70124021	70124021	2002799-001
			407705-006	407705-006	2002800-001
			70124035	70124035	2010458-001
			414248-001	414248-001	2010459-001
			70124033	70124033	2010462-001
			70124034	70124034	2010463-001
			70124027	70124027	2010469-001
			70124022	70124022	2010460-001
			70124026	70124026	2010461-001
			70124032	70124032	2010477-001
			2028117-001	2028117-001	2010466-001
			407705-004		2009745-001
			407705-001		2009743-001
			407705-002		2027269-001
			407705-003		2027270-001
					2027271-001
					2027273-001
					2027274-001
					2027276-001
					2027277-001

Tram Module Dual BP Adapter Cable

The Tram 451 series modules can monitor four invasive blood pressures when a dual BP adapter cable is used. This cable plugs into the **BP3** connector on the module, and allows two separate invasive blood pressures to be monitored from that connector.



Tram 451N/451N5 module with dual BP adapter cable connected to BP3 connector

This cable is designed to fit only in the **BP3** connector. Do not attempt to plug it into any other connector; it will not function.

The dual BP adapter cable can ONLY be used with Tram 451 series modules. It cannot be used with any other Tram module series.

Start Up

After inserting the module, the module should identify itself on the monitor screen with a patient parameter box.

If the module does not identify itself on the screen, refer to "Troubleshooting Procedure" in Chapter 6, Troubleshooting.

Perform the "Checkout Procedure" provided in Chapter 5, Maintenance.

For your notes

3 Connections

For your notes

External Connectors

Pin numbers and signal names for each connector on the front panel and rear of the module are described in this section. Each module uses a "bristle brush" connector to interface to the backplane of the Tram-rac housing.

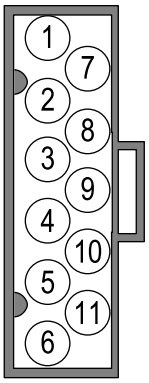
Blood Pressure

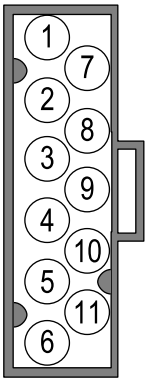
Invasive blood pressure transducers connect to the Tram modules at the BP connectors. The left and middle BP connector on the Tram 451, 451N, 451N5, and 451M modules are all functionally the same, so the first connector diagram applies to those connectors.

The right BP connector can be used the same as the other two BP connectors to provide a third BP channel. When used with a Dual BP Adapter Cable, the right BP connector provides both a third and fourth BP channel. The second connector diagram applies to the right BP connector.

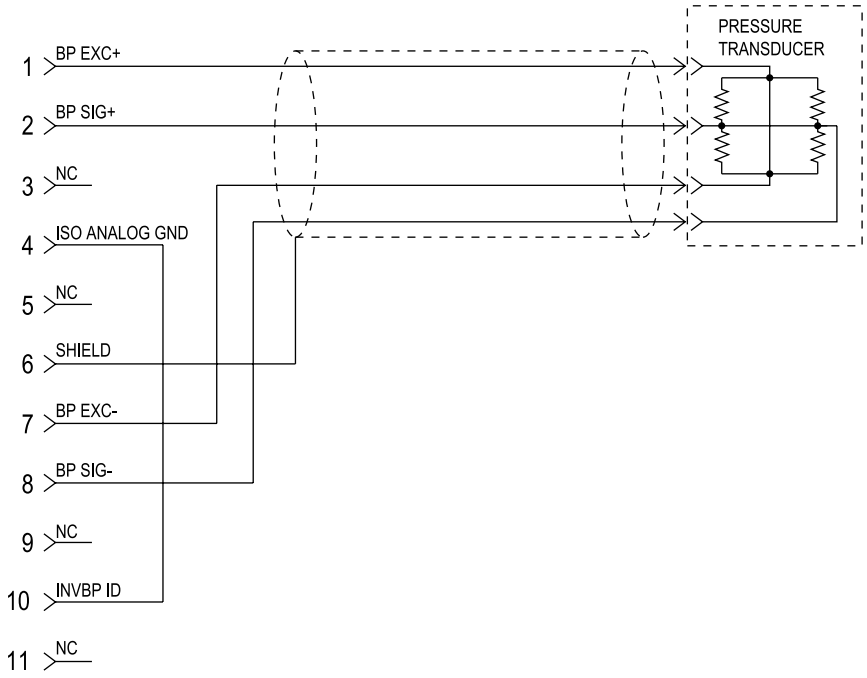
BP cables for the Tram modules are available for the following transducers:

- Abbott Transpac II transducers use pn 700074-001
- Abbott Transpac III transducers use pn 700075-001
- American Edwards transducers use pn 700076-001
- Spectramed transducers use pn 700077-001
- Utah transducers use pn 700078-002

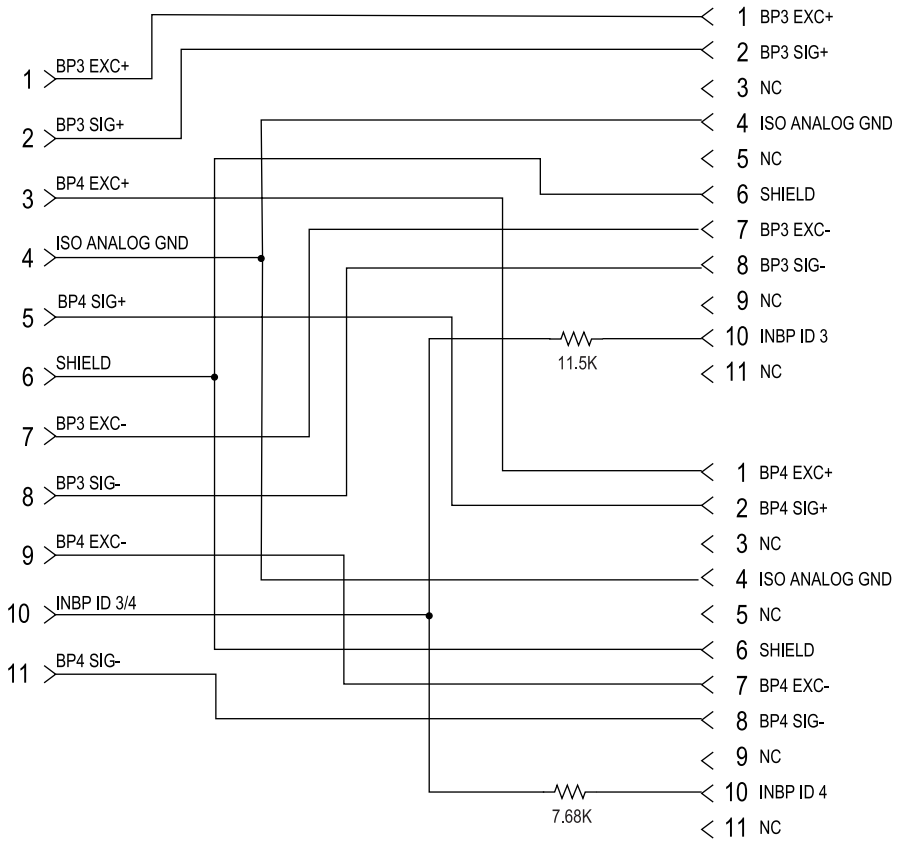
BP Front Connector			
Pin	**Name**	**Type**	
1	BP_EXC+	Positive excitation voltage (output)	 **Front View of Red-Colored BP Connector**
2	BP_SIG+	Positive analog pressure signal from transducer	
3	NC		
4	ISO_ANALOG_GND	Isolated analog ground reference	
5	NC		
6	SHIELD	Cable shield	
7	BP_EXC–	Negative excitation voltage (output)	
8	BP_SIG–	Negative analog pressure signal from transducer	
9	NC		
10	INVBP_ID	When you connect this pin to ISO ANALOG GND (pin 4), the monitor show the BP trace for this connector	
11	NC		

Dual BP Front Connector			
Pin	**Name**	**Type**	
1	BP3_EXC+	BP3 positive excitation voltage (output)	 **Front View of Red-Colored BP Connector**
2	BP3_SIG+	BP3 positive analog pressure signal from transducer	
3	BP4_EXC+	BP4 positive excitation voltage (output)	
4	ISO_ANALOG_GND	Isolated analog ground reference	
5	BP4_SIG+	BP4 positive analog pressure signal from transducer	
6	SHIELD	Cable shield	
7	BP3_EXC–	BP3 negative excitation voltage (output)	
8	BP3_SIG–	BP3 negative analog pressure signal from transducer	
9	BP4_EXC–	BP4 negative excitation voltage (output)	
10	INBP_ID 3/4	When this pin is connected to ISO ANALOG GND (pin 4), the monitor shows the BP3 trace for this connector. When the Dual BP Adapter Cable is plugged in, this pin determines if the BP3 and/or BP4 cables are plugged in to the adapter.	
11	BP4_SIG–	BP4 negative analog pressure signal from transducer	

Below is the schematic diagram of the blood pressure probe sensor.



Below is the schematic diagram of the Dual BP Adapter Cable.



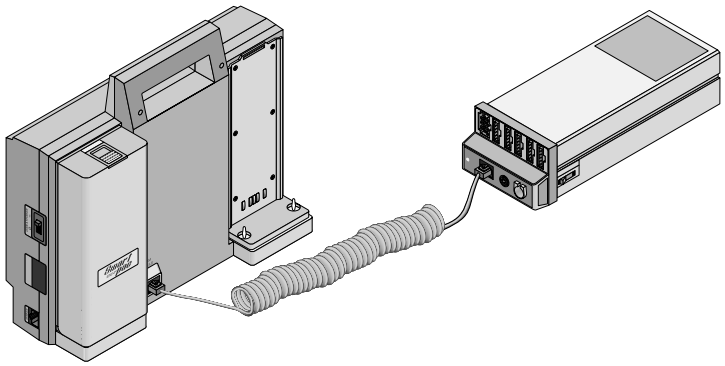
DEFIB SYNC

The **DEFIB SYNC** connector carries signals for interfacing with a defibrillator. It also has analog output signals for ECG traces and ART BP. If you need to connect a defibrillator with the module, a 15-foot defibrillator cable is available. It has a DEFIB SYNC connector on one end and it is unterminated at the other end.

Defibrillator Synchronization connector J2			
Pin	**Name**	**Descriptions**	
1	DEFIB_MARKER_OUT	Digital defibrillator output synchronization signal	
2	DEFIB_MARKER_IN	Digital defibrillator input signal	
3	AGND1	Signal Ground	
4	DGND	Signal Ground	
5	AGND2	Signal Ground	
6	BP_ANALOG_OUTPUT	Analog BP output signal	
7	ECG_ANALOG_OUTPUT	Analog ECG output signal	**Front View of Module**

DISPLAY

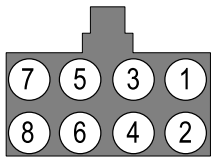
The **DISPLAY** connector carries communication and power signals between the Tram module and a transport display. Note that the Tram module must be connected to the connector on the rear of the transport display. If you plug it into one of the side connectors, a large *COMMUNICATION FAILURE* message appears.



Use any of these cables to connect the Tram module to a transport display.

Display Cables		
Part Number	**Length (Feet)**	**Length (Meters)**
403495-001	10	3
403496-001	15	4.6
406468-002	25	7.6
406468-001	40	12.2

Display Connector			
Pin	**Name**	**Description**	
1	DLK_TXD+	RS422 output[1]	
2	DLK_TXD–	RS422 output[1]	
3	DLK_RXD+	RS422 input[1]	
4	DLK_RXD–	RS422 input[1]	
5	PWRRTN	Power Bus and +16.5V ground	
6	SENSE_OUT	The transport display connects this signal to PWRRTN to turn the Tram module on.	
7	+16.5V	A 16.5-volt output that powers the transport display when you install the Tram module in a monitor.	
8	PWRBUS	A 10 to 16.75-volt power input from the transport display.	



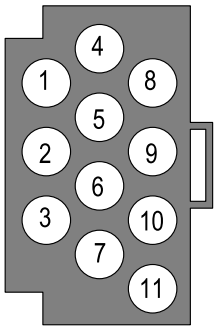
Front View of Module

1. 38.4k b/s, 8 bit, no parity, 1 stop bit.

ECG/RESP

ECG patient cables attach to the ECG/RESP connector. In addition to the ECG leadwire, the signals on this connector include a 52.6-kHz respiration carrier.

ECG/RESP Connector			
Pin	**Name**	**Description**	
1	RA	Right arm limb leadwire	
2	V2	V2 chest leadwire	
3	V3	V3 chest leadwire	
4	LA	Left arm limb leadwire	
5	RL	Right leg limb leadwire	
6	V/V1	V (during 3 or 5-leadwire use) or V1 (during 10-leadwire use) for chest leadwire	
7	V4	V4 chest leadwire	
8	LL	Left leg limb leadwire	
9	V6	V6 chest leadwire	
10	V5	V5 chest leadwire	
11	SHIELD	Cable shield	

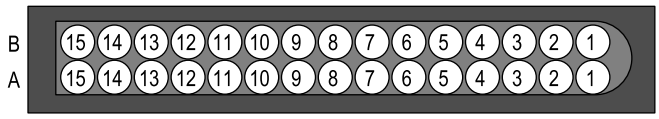


Front View of Green-Colored ECG Connector

Rear Connector

Tram-rac housings connect to the Tram module at the **MONITOR** connector. This is the only connector on the Tram module's rear panel. The **MONITOR** connector carries power, communication, and analog output signals between the Tram module and a monitor.

Rear Module Connector



Pin	Name	Description
A1	AGND	Non-isolated analog ground reference
A2	XMIT_EN*	When installed in a Tram-rac housing, the Tram module asserts this CMOS output signal to enable Tram-net communication drivers in the Tram-rac housing.
A3	SYNC_ECG_RTN	Ground reference for SYNC ECG on pin 4A.
A4	SYNC_ECG	ECG x10 analog output for the top displayed ECG trace
A5	MOD DATA CLK*	Clock input for synchronous shift register communications with a Series 7XXX monitor[1]. Toggles to clock data to a monitor (across MOD DATA OUT) or from a monitor (across MOD DATA IN). This signal toggles 32 times and then goes high to disable Tram module communications while reading from other modules.
A6	MOD_LOAD_DATA_IN*	Module data input. A CMOS signal used with Tram-net communication from Tram-rac housings.
A7	MOD_DATA_OUT*	Module data output. A CMOS signal used with Tram-net communication to Tram-rac housings.
A8	MOD_DATA_LCH*	Synchronous shift register communication latch input from Series 7XXX monitor[1]. Goes high to signal to the module that it should latch onto the last 32 bits of data sent across MOD DATA IN.
A9	BP3	10 mV/mmHg analog output for BP3 blood pressure trace; outputs SpO_2 value x 10 mV if BP3 isn't cabled; outputs buzz[2] if BP3 is not zeroed
A10	NC	
A11	GND	Non-isolated digital ground reference
A12	BKPLANE_ID	A +5-volt input, supplied only by Tram-rac housings with Tram-net communications.
A13	NC	
A14	NC	
A15	AGND	Non-isolated analog ground reference
B1	ART_BP	10 mV/mmHg analog output for top ART blood pressure trace; outputs BP1 trace if no ART trace is displayed; outputs buzz† if ART/BP1 is not zeroed.

Rear Module Connector		
B2	MOD_ENABLE	An input that the 70XX monitor[1] asserts to enable synchronous serial shift register communication with the Tram module.
B3	BP2	10 mV/mmHg analog output for BP2 blood pressure trace; outputs SpO_2 trace if BP2 is not cabled; outputs buzz[2] if BP2 is not zeroed
B4	+16.5V	A 16.5-volt input that powers the Tram module (and, if connected, the transport display)
B5	PWRBUS	16.75-volt power input
B6	TRC2/ECGI	ECG x1000 analog output for lead II. If lead II fails, this signal reverts to buzz[2]
B7	TRC1/ECGI	ECG x1000 analog output for the top displayed ECG trace. This signal reverts to buzz[2] during leads fail condition
B8	ECGV	ECG x1000 analog output for lead V. If lead V fails, this signal reverts to buzz[2]
B9	NC	
B10	BP4	10mV/mmHg analog output for BP4 blood pressure trace; outputs RESP waveform (without markers) if BP4 is not cabled; outputs buzz[1] if BP4 is not zeroed
B11	GND	Non-isolated digital ground reference
B12	+5V	A +5-volt input, used to determine that the Tram module is installed in a monitor.
B13	NC	
B14	NC	
B15	AGND	Non-isolated analog ground reference

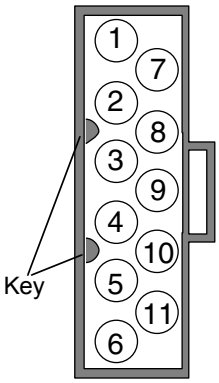
1. Tram X51 modules do not support the series 7XXX monitor.
2. Buzz is a 60-Hz, 1-volt peak-to-peak triangle waveform centered around 0 volts. It is not perfectly shaped and only indicates the trace is in a failed condition.

GE Ohmeda SpO_2 (451 and 851)

The GE Medical Systems *Information Technologies* and Nellcor non-invasive pulse oximetry probes connect to the Tram X51 modules with a square-style SpO_2 connector. This connector carries the red and infrared light source drive outputs and the photo detector and probe type inputs. The Nellcor or Nellcor OxiSmart SpO_2 patient cables attach to the front panel 11-pin blue Nicolay SpO_2 connector.

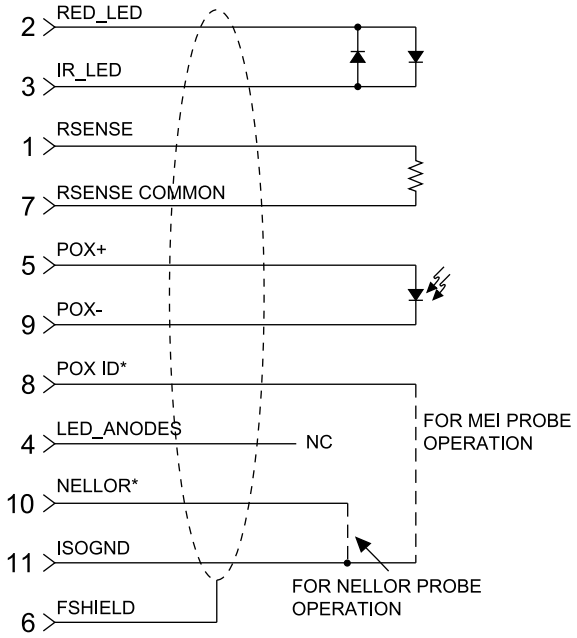
GE Ohmeda SpO_2 Connector

Pin	Name	Description
1	RSENSE	Probe characteristics ID resistor measurement
2	RED_LED	Red LED cathode (RED LED source)
3	IR_LED	Infrared light source cathode (Infrared LED source)
4	LED_ANODES	NC
5	POX+	Photodetector anode
6	FSHIELD	Cable shield
7	RSENSE COMMON	Common return for RSENSE signal
8	POX_ID*	Tied to ISOGND for MEI probe identification
9	POX–	Photodetector cathode
10	NELLCOR*	Tied to ISOGND for Nellcor probe identification
11	ISOGND	Ground reference for PRB_SENSE and NELLCOR* signals



Front View GE Ohmeda Blue-Colored SpO_2 Connector

Below is the schematic diagram of the GE Medical Systems *Information Technologies* and nellcor probe sensor.

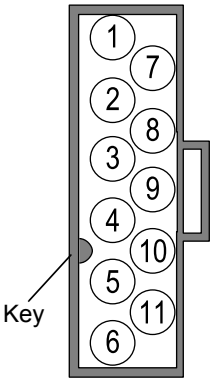


Nellcor OxiSmart SpO_2 (451N and 851N)

Nellcor OxiSmart non-invasive pulse oximetry probes connect to the Tram X51N modules with the square-style SpO2 connector. This connector carries the red and infrared light source drive outputs and the photo detector and probe type inputs. The Nellcor OxiSmart SpO_2 patient cable attaches to the front panel 11-pin blue Nicolay SpO_2 connector

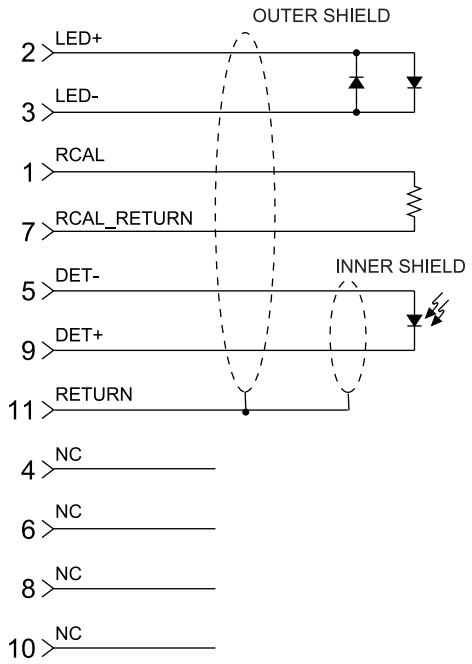
Nellcor OxiSmart SpO_2 Connector

Pin	Name	Description
1	RCAL	Probe ID resistor
2	LED+	Positive LED drive
3	LED-	Negative LED drive
4	NC	No connection
5	DET-	Negative photo detector signal
6	NC	No connection
7	RCAL_RETURN	Return for RCAL
8	NC	No connection
9	DET+	Positive photo detector signal
10	NC	No connection
11	RETURN	Isolated ground



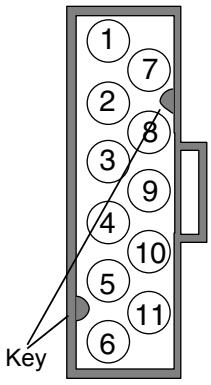
Front View Nellcor Blue-Colored SpO_2 Connector

Below is the schematic diagram of the Nellcor OxiSmart probe sensor.

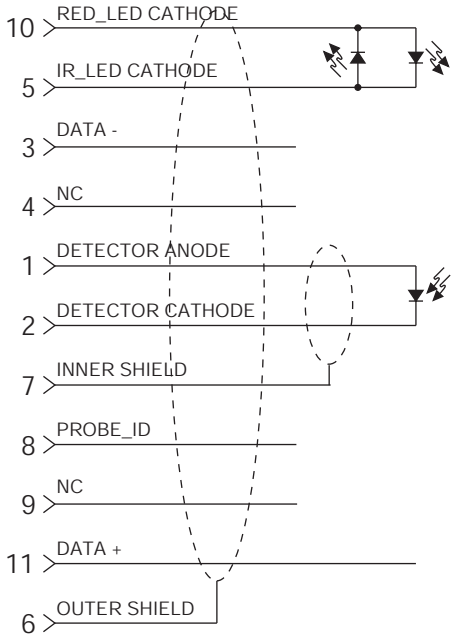


Nellcor OxiMax SpO_2 (451N5 and 851N5)

Nellcor OxiMax non-invasive pulse oximetry probes connect to the Tram 451N5 and 851N5 modules with the square-style SpO2 connector. This connector carries the red and infrared light source drive outputs and the photo detector and probe type inputs. The Nellcor OxiMax SpO_2 patient cable attaches to the front panel 11-pin Blue Nicolay SpO_2 connector.

	Nellcor OxiMax SpO_2 Connector			
Pin	**Signal Name**	**Type**	**Description**	
1	Detector Anode	I	Detector Anode	 **Front View Nellcor OxiMax Blue-Colored SpO_2 Connector**
2	Detector Cathode	I	Detector Cathode	
3	Data –	X	1-wire data – (cable memory)	
4	NC	X	No connection	
5	IR LED Cathode	O	IR LED Cathode/Red LED Anode	
6	Outer Shield	O	Outer shield of patient cable	
7	Inner Shield	O	Inner shield (shield around detector wires of patient cable)	
8	Probe ID	X	ID resister (not used)	
9	NC	X	No connection	
10	RED LED Cathode	O	Red LED Cathode/IR LED Anode	
11	Data +	O	1-wire data + (cable memory)	

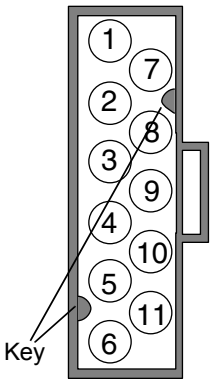
Below is the schematic diagram of the Nellcor OxiMax probe sensor.



Masimo SpO_2 (451M and 851M)

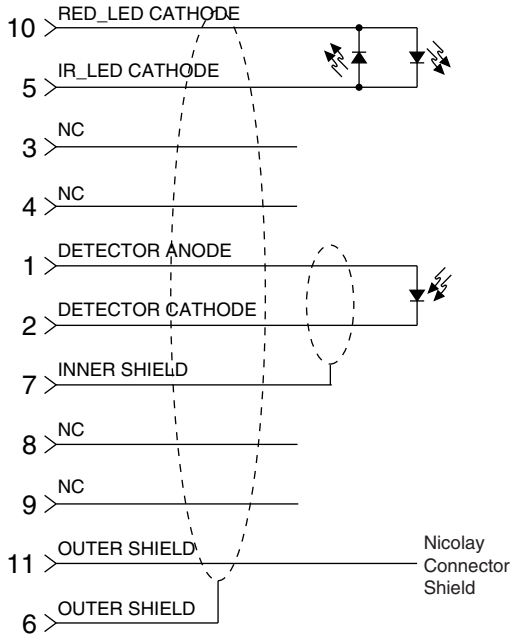
Masimo non-invasive pulse oximetry probes connect to the Tram X51M modules with the square-style SpO2 connector. This connector carries the red and infrared light source drive outputs and the photo detector and probe type inputs. The Masimo SpO_2 patient cable attaches to the front panel 11-pin Blue Nicolay SpO_2 connector.

	Masimo SpO_2 Connector			
Pin	**Signal Name**	**Type**	**Description**	
1	Detector Anode	I	Detector Anode	
2	Detector Cathode	I	Detector Cathode	
3	NC	X	No connection	
4	NC	X	No connection	
5	IR LED Cathode	O	IR LED Cathode/Red LED Anode	
6	Outer Shield	O	Outer shield of patient cable	
7	Inner Shield	O	Inner shield (shield around detector wires of patient cable)	
8	NC	X	No connection	
9	NC	X	No connection	
10	RED LED Cathode	O	Red LED Cathode/IR LED Anode	
11	Outer Shield	O	Outer shield of Nicolay connector	



Front View Masimo Blue-Colored SpO_2 Connector

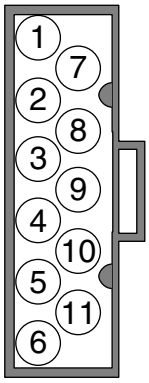
Below is the schematic diagram of the Masimo probe sensor.



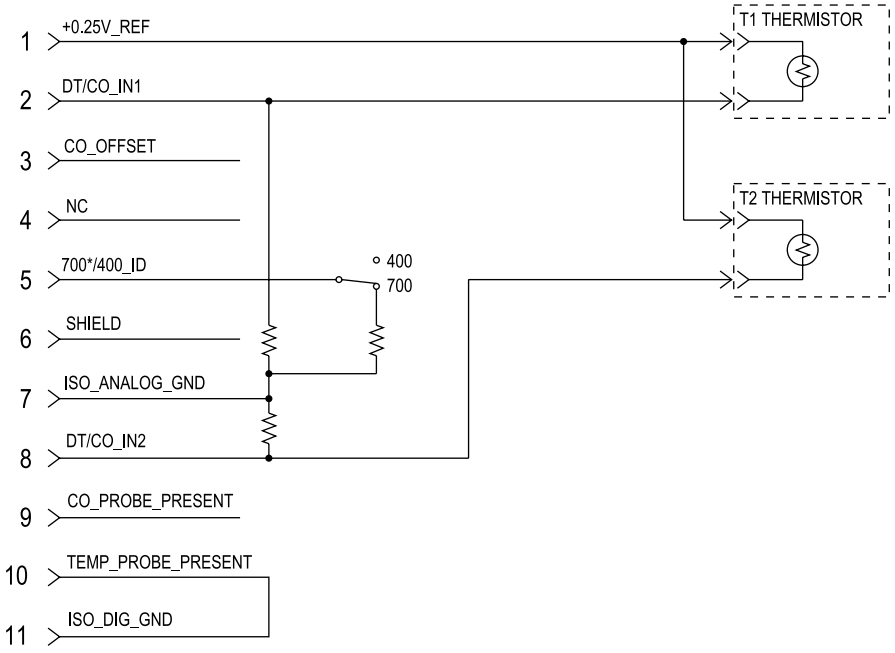
TEMP/CO Connector

Thermistors and cardiac output probes connect to the Tram module at the **TEMP/CO** connector.

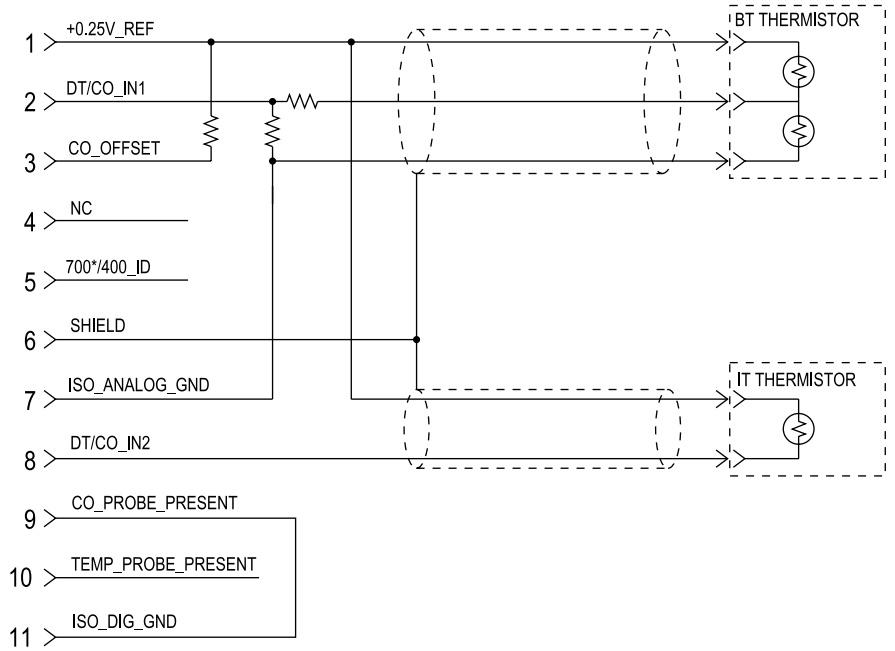
If you have existing temperature or cardiac output cables, termination kits can be ordered so you can use the cables with your Tram module.

CO Front Connector			
Pin	**Name**	**Type**	 **Front View of Brown-Colored TEMP/CO Connector**
1	0.25VD REF	A stable +0.25-volt reference output for the thermistors	
2	DT/CO IN1	Channel 1 input	
3	CO_OFFSET	Catheter offset reference voltage	
4	NC		
5	700*/400ID	The TEMP cable connects this input to ISO_DIG_GND when YSI series 700 thermistors are used, and leaves it floating when YSI series 400 thermistors are used	
6	SHIELD	Cable shields are connected here	
7	ISO_ANALOG_GND	Isolated analog ground reference	
8	DT/CO IN2	Channel 2 input	
9	CO_PROBE_PRESENT	CO cables connect this input to ISO_DIG_GND to show that they are connected.	
10	TEMP_PROBE_PRESENT	TEMP cables connect this input to ISO_DIG_GND to show that they are connected.	
11	ISO_DIG_GND	Isolated digital ground	

Below is the schematic diagram of a TEMP cable/thermistor.



Below is the schematic diagram of the typical CO cable/thermistor.



4 Calibration

For your notes

Adjustments, Jumpers, and Switches

The following list summarizes Tram module's switches, jumpers, and adjustments. The following pages contain detailed procedures for setting these items.

> **CAUTION**
> These adjustments are intended to be made by a qualified trained technician. Do not 'experiment' with these adjustments without understanding the affect on the equipment.

Power Supply PCB

- R14 – Power supply clock frequency adjustment

Module Processor PCB

- W1 – Defib sync level jumper
- W2 – Defib sync duration jumper
- W3 – Battery disconnect jumper
- S1 – Various software and hardware configuration switches
- C2 – Real-time clock frequency adjustment
- R64 – Battery low voltage trip point adjustment

Acquisition Processor PCB

- R35 – Analog-to-digital converter offset adjustment
- R37 – Analog-to-digital converter gain adjustment

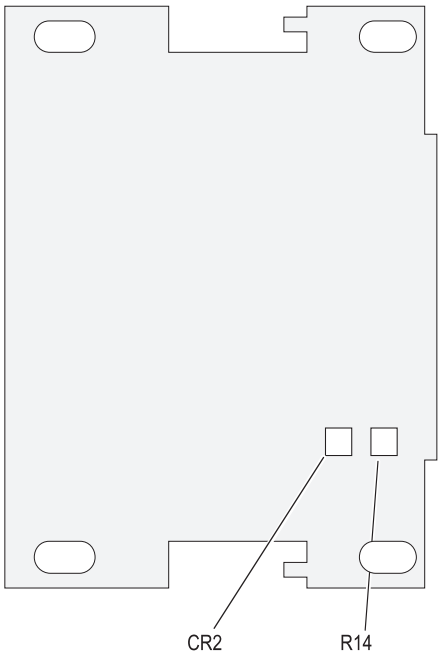
This chapter also includes non-invasive blood pressure (NBP) calibration procedures. These calibration procedures are performed through software, and do not require manual adjustments.

Power Supply Clock Frequency Calibration

The following procedure sets the frequency of the clock oscillator for the power supply. This procedure is only necessary when the power supply PCB has been repaired or replaced.

This PCB is made almost entirely of CMOS components and is highly susceptible to ESD damage.

1. Remove the outside covers, shielding plates, etc. from the Tram module. Remove four screws that secure the power supply PCB to the frame to access the adjustments.
2. Apply power to the Tram module by connecting a Smart-pac Transport display to the front panel connector of the Tram module.
3. Wait at least two minutes to warm up the pulse width modulator.
4. Connect a frequency counter across diode CR2.
5. Adjust variable resistor R14 until the frequency counter reads 95.0 kHz (±1.0 kHz).

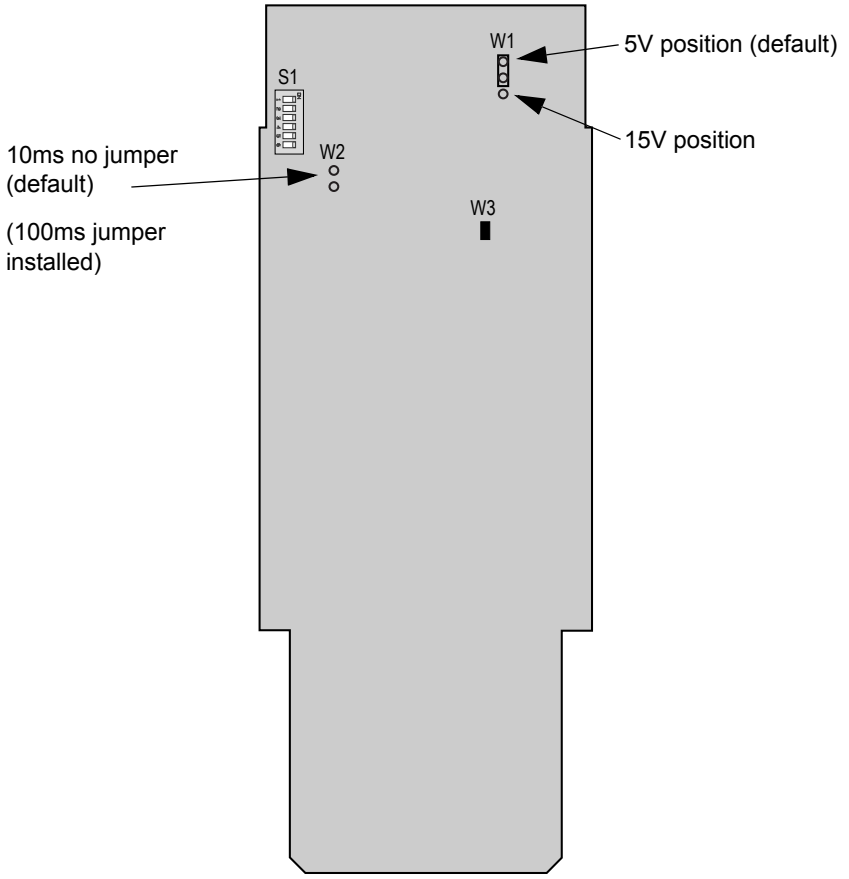


6. Seal the end of variable resistor R14 to prevent it from moving.
7. Remove power from the Tram module.
8. Reassemble the Tram module.

Module Processor PCB

Jumpers

The jumper positions shown are the factory defaults. There are three jumpers on this circuit board as follows:



W1 – This jumper controls the output level of the defib sync pulse through the front panel connector. This jumper can be placed in one of two positions:

- 5V – install a jumper in this location if the defibrillator used with the Tram module needs a 5-volt pulse, or
- 15V – install a jumper in this location if the defibrillator used with the Tram module needs a 15-volt pulse.

This jumper is in the 5V position on new Tram modules.

W2 – This jumper controls the pulse width of the defib sync pulse:

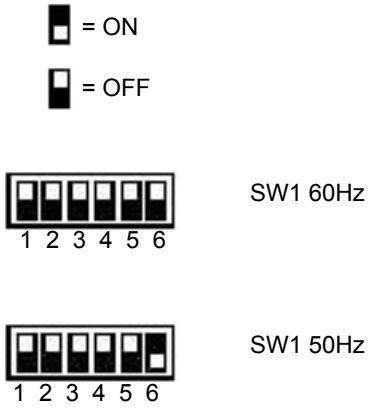
- install this jumper for a 100-millisecond pulse, or
- remove this jumper for a 10-millisecond pulse.

This jumper is not installed on new Tram modules.

W3 – Remove this jumper to remove battery BT1 from the circuit for calibration and testing. Jumper W3 must be in place for proper operation.

Switches

Switch S1 is the only switch on the module processor PCB. It is a 6-station dip switch used to configure both hardware and software parameters. The following are the functions of each of the individual switch stations.

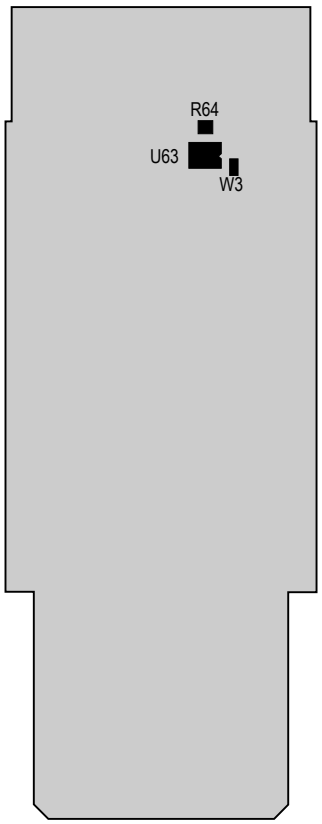


Switch	Function
SW1	Not used (set to OFF)
SW2	Not used (set to OFF)
SW3	Enables or disables software updates and NBP calibration on all Tram modules. ■ ON – disables software updates and NBP calibration. Position to OFF for NBP calibration. ■ OFF – normal operation
SW4	Enables Tram integral battery option
SW5	Not used (set to OFF)
SW6	Power frequency select ■ ON – 50Hz ■ OFF – 60Hz

Battery Low Voltage Trip-Point Calibration

The module processor PCB contains battery-backed static RAM. The battery is a 3.0-volt battery, and is deemed too low to power the RAM when it has drained to the point where it only supplies 2.1 volts. This adjustment ensures that the Tram module notifies the transport display when the battery reaches the 2.1-volt level. The transport display then displays service message *CALL SERVICE 208* notifying the user that the battery should be changed.

This calibration is only necessary when the module processor is removed and replaced. The position of the jumpers depends on the version of the circuit board.



1. Remove jumper W3.
2. Turn variable resistor R64 fully clockwise. Some boards use a Murata Erie variable resistors for R64. These variable resistors have no positive mechanical stops, so you'll have to estimate full clockwise as best you can.
3. Apply an adjustable voltage source, set to 3.0 volts, to the W3 socket that is closest to the edge of the circuit board. The ground of the voltage source should be attached to a ground on the circuit board (pin 4 of U63).
4. Verify pin 10 of U63 is a logic high.
5. Adjust the voltage source slowly down to 2.1 volts. Avoid undershooting the voltage.

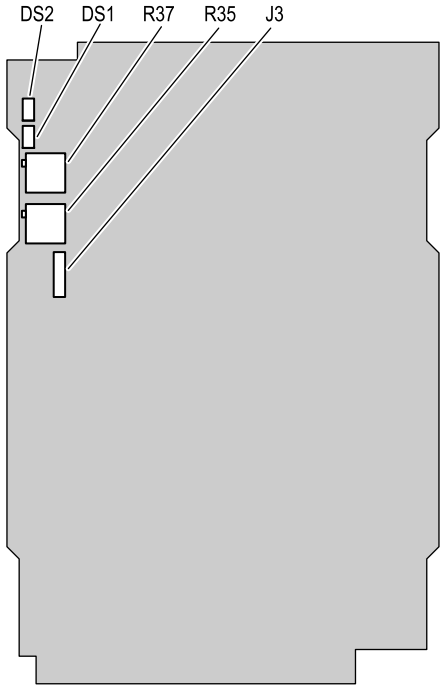
6. Observe the logic level of pin 10 of U63 while slowly turning the variable resistor R64 counter-clockwise. When the logic level of U63-10 goes low, stop turning.
7. Test this adjustment by ramping the power source from 3 volts to 2.1 volts again. Pin 10 of U63 should switch from a high to a low state at 2.1 volts ±50 millivolts.
8. Seal the end of variable resistor R64 to prevent it from moving.
9. Remove power from the Tram module.
10. Reassemble the Tram module.
11. Perform the Checkout Procedure, Current Leakage Tests, and Hi-Pot tests listed in Chapter 5, Maintenance.

Acquisition Processor PCB Analog-to-Digital Converter Calibration

The following procedure accurately sets the zero offset and gain of the analog-to-digital converter on the acquisition processor PCB. This procedure is only necessary when the acquisition processor PCB has been repaired or replaced.

NOTE

This PCB uses many CMOS components, and when exposed to outside influences is highly susceptible to ESD damage.



1. Expose the data acquisition module by removing the outside covers, shielding plates, etc. from the Tram module.
2. Remove the top cover of the data acquisition module to reveal the acquisition processor PCB.
3. Apply power to the Tram module. The easiest way to do this is to connect a transport display with a battery pack to the front panel connector of the Tram module.
4. Jumper pins 2 and 3 of connector J3 together to enable the calibration mode. LEDs DS1 and DS2 will blink 5 times simultaneously to indicate the calibration mode is enabled.
5. Connect a low-noise, precision voltage source to the acquisition processor at pins 1 (+) and 4 (–) of connector J3. Set the voltage source to output –9.9976 volts.

6. If the offset adjustment of the analog-to-digital converter is inaccurate, either DS1 or DS2 will light.
   - If DS1 lights, rotate variable resistor R35 clockwise until both lights are off.
   - If DS2 lights, rotate variable resistor R35 counter-clockwise until both lights are off.

   Occasional blinking of the LEDs throughout the calibration procedure is normal. It doesn't necessarily mean that calibration is necessary again.
7. Adjust the voltage source to +9.9927 volts.
8. If the gain adjustment of the analog-to-digital converter is inaccurate, either DS1 or DS2 will light.
   - If DS1 lights, rotate variable resistor R37 clockwise until both LEDs are off.
   - If DS2 lights, rotate variable resistor R37 counter-clockwise until both LEDs are off.
9. Seal the end of variable resistors R35 and R37 to prevent them from moving.
10. Remove all power from the Tram module.
11. Remove the jumper from J3 and reassemble the Tram module.
12. Perform the Checkout Procedure, Current Leakage Tests, and Hi-Pot tests listed in Chapter 5, Maintenance.

NBP Calibration

Accuracy

The accuracy of your non-invasive blood pressure (NBP) readings depends on the accuracy of two things:

- the zero pressure reading, and
- the voltage span of the NBP sensor in the module.

In this procedure you'll make sure that both of these items are accurate, and you'll check for NBP plumbing leaks at the same time.

Frequency

Perform this procedure:

- upon receipt of the device,
- every twelve months thereafter,
- each time the main enclosure is disassembled or a circuit board is removed, tested, repaired or replaced.

Special Equipment/Tools

- A Tram-compatible monitor
- A digital or mercury manometer (Meriam Instrument Smart Manometer Model 350 DM2000 or equivalent)
- An NBP tube (414873-001)
- An NBP cuff (9461-301)
- PVC pipe
- NBP cuff coupling (400787-001)
- NBP hose coupling (46100-002)
- NBP tee (4745-101)
- NBP tubing (401582-001)

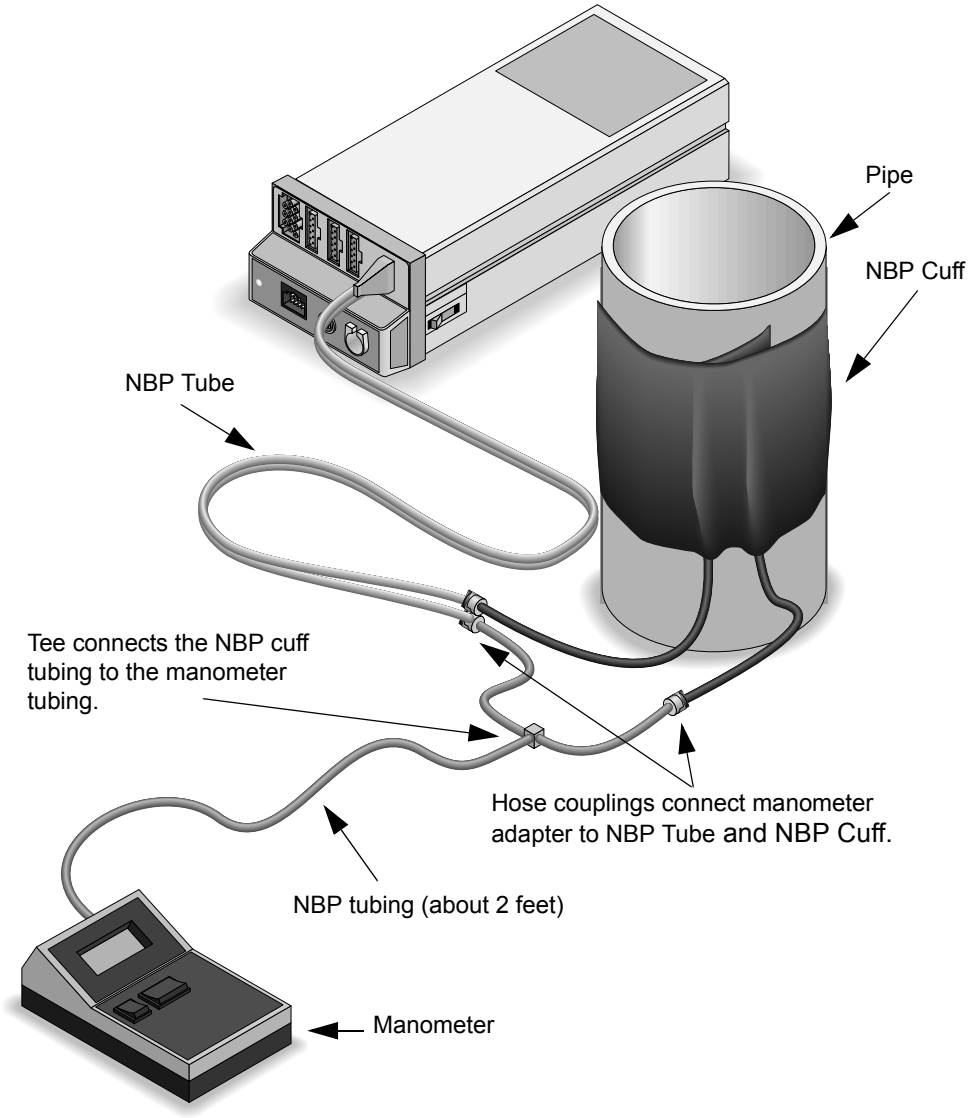
Preparation

Insert the module in the top slot of a Tram-rac 4 housing.

1. Disconnect all parameter cables
2. Apply power to the monitor. If your Tram-rac housing has its own power supply, apply power.
3. Ensure POWER indicator on the Tram module's front panel is turned ON.

WARNING
When the NBP cuff is used in this procedure, it must be tightly wrapped around a tube. DO NOT place the cuff around your arm during the calibration procedures.

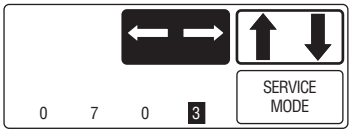
1. Connect a manometer and NBP cuff to the NBP connector on the front of the Tram module as shown below.


Pipe
NBP Cuff
NBP Tube
Tee connects the NBP cuff tubing to the manometer tubing.
Hose couplings connect manometer adapter to NBP Tube and NBP Cuff.
NBP tubing (about 2 feet)
Manometer

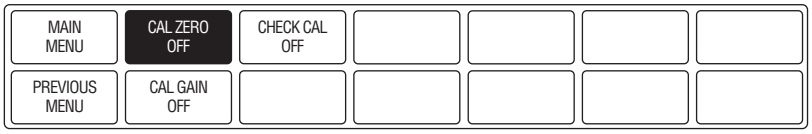
2. Turn the manometer ON, and set its range switch to the 1000 mmHg setting.

NBP Test

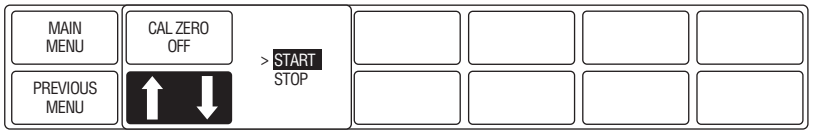
1. Remove the NBP tubing from the front of the Tram.
2. From the monitor's main menu, select *MONITOR SETUP*.
3. Select *SERVICE MODE*.
4. Enter the password to get into the service mode.
   - The first two digits of the password are the day of the month, and the second two digits are the month. For example, on 7 March, the password would be 0703.
   - Select *SERVICE MODE*.



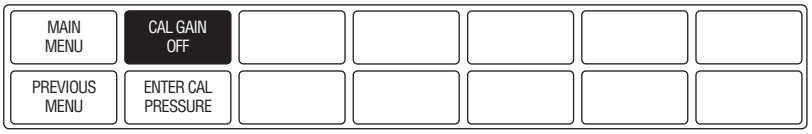
5. Select *CALIBRATE NBP*.
6. Select *CAL ZERO OFF*.



7. Select *START*. The *CAL ZERO* menu item shows that it is *IN PROGRESS*, and when it is done it displays *OFF* again.



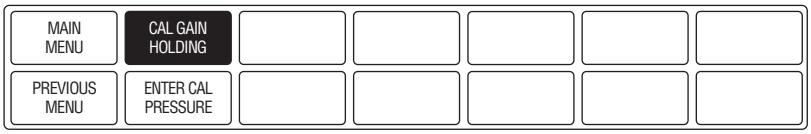
8. Reconnect the NBP tubing to the Tram.
9. Select *CAL GAIN OFF*.



10. Select *START*.

The second line of text on the *CAL GAIN* menu item changes to *INFLATING*. Then, the Tram module starts pumping up the pressure bulb or cuff displayed pressures increase on both the monitor display and the manometer.

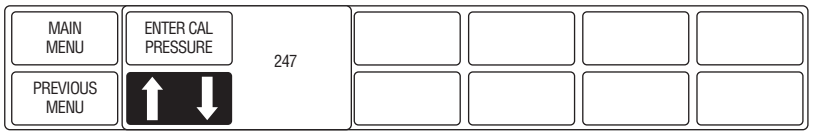
The pump shuts off at about 250 mmHg, and the pressure drops slowly to about 240 mmHg before stabilizing. The second line of text on the *CAL GAIN* menu item changes from *INFLATING* to *HOLDING*.



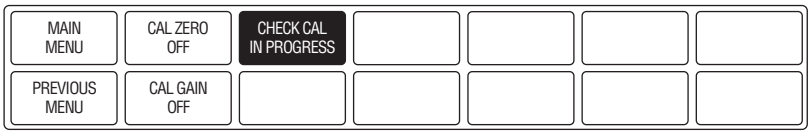
NOTE

If the pressure continues to drop at a rate of 1 mmHg or more for every five seconds, there is a leak in the NBP plumbing. If there is a leak in the NBP plumbing, repair it and restart this calibration procedure.

11. Select *ENTER CAL PRESSURE*.
12. An *ENTER CAL PRESSURE* popup window appears. Use the **Trim Knob** control to select a pressure value that is 1 mmHg lower than the current manometer reading.



13. When the manometer falls to exactly the value that you selected in the popup window, press the **Trim Knob** control to enter the value. Select *PREVIOUS MENU* to return to the *MAIN MENU* button.
14. Select *CHECK CAL OF*F.
15. Select *START*.
16. The text on the menu item changes from *CHECK CAL OFF* to *CHECK CAL IN PROGRESS*. Make sure that the pressure readings (shown as *CUFF* in the NBP parameter box) on the monitor display and manometer are equal (± 1 mmHg) for at least one full minute.
17. Select *CHECK CAL IN PROGRESS*.



18. Select *STOP*. The module then releases pressure in the bulb or cuff.
19. Remove the cuff and manometer from the Tram module.

5 Maintenance

For your notes

Maintenance Schedule

Manufacturer Recommendations

To make sure the Tram module hardware remains in proper operational and functional order, a good maintenance schedule must be adhered to. The manufacturer recommends the following:

- **Visual Inspection:** Performed by service personnel upon receipt of the equipment, one time per year thereafter, and prior to servicing the unit.
- **Cleaning:** Performed by service personnel upon receipt of the equipment, one time per year thereafter, and each time the unit is serviced.
- **Calibration:** NBP required every twelve months.
- **Electrical Safety Checks:** Performed by service personnel upon receipt of the equipment, one time per year thereafter, and each time the unit is serviced.
- **Checkout Procedure:** Performed by qualified service personnel upon receipt of the equipment, one time per year thereafter, and each time the unit is serviced.
- **Clearing the Stored Patient Data Memory:** Admit and discharge a test patient every twelve months to clear the stored patient data memory.

Manufacturer Responsibility

WARNING
Failure on the part of all responsible individuals, hospitals or institutions, employing the use of this device, to implement the recommended maintenance schedule may cause equipment failure and possible health hazards. The manufacturer does not, in any manner, assume the responsibility for performing the recommended maintenance schedule, unless an Equipment Maintenance Agreement exists. The sole responsibility rests with the individuals, hospitals, or institutions utilizing the device.

Inspection and Cleaning

Visual Inspection

Remove module before making an inspection or cleaning the module.

- Check the case for cracks or other damage.
- Regularly inspect cables for fraying or other damage.
- Inspect all plugs, cables, and connectors for bent prongs or pins.
- Verify that all cables and connectors are securely seated. Note, components should only be replaced by qualified service personnel.

Cleaning Precautions

Use one of the following approved solutions:

- Cidex solution, or
- Sodium hypochlorite bleach (diluted), or
- Mild soap (diluted)
- Lint-free cloth
- Dust Remover (compressed air)

To avoid damage to the equipment surfaces, do not use the following cleaning agents:

- organic solvents,
- ammonia based solutions,
- acetone solution,
- alcohol based cleaning agents,
- Bentadine solution,
- a wax containing a cleaning substance, or
- abrasive cleaning agents.

Exterior Cleaning

Clean the exterior surfaces with a clean, lint-free cloth and one of the cleaning solutions listed above.

- Wring the excess water from the cloth. Do not drip any liquid into open vents, plugs, or connectors.
- Dry the surfaces with a clean cloth or paper towel.

Checkout Procedure

The following pages describe the checkout procedures for the Tram module. These procedures verify the operational performance of the Tram module. If you do not get the results listed in the procedures, your Tram module might not be working properly.

Perform all tests applicable to your Tram module in the order listed.

Test Frequency

This procedure tests the functions of each parameter of the module. We recommend this checkout procedure be performed:

- upon receipt of the module,
- once a year, and
- each time the module is open or repaired.

Record the date and results on the "Maintenance/Repair Log" included at the end of this chapter.

Required Tools/Special Equipment

NOTE

Be sure test equipment is maintained according to manufacturer's maintenance schedule to ensure accuracy.

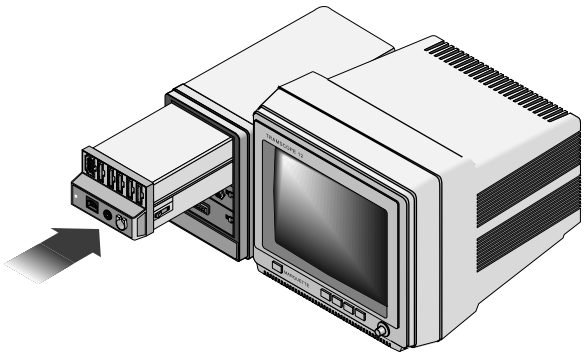
The following table lists the test equipment, adapters, and cables necessary to complete the checkout procedures.

Host Monitor ■ Solar 8000, 8000i, 8000M, 9500
Patient Simulators and Cables ■ Marq-I with Cardiac Output Simulator II (900028-001) (no longer available for ordering) ■ MarqII-KIT (includes CO injectate box) ■ ECG Patient Cable ■ ECG Leadwire Set
Blood Pressure Test: ■ Blood Pressure Simulator Cable (700095-001)
Temperature Test: ■ 700/400 Series Dual Temperature Adapter (402015-004) ■ Temperature Simulator Cable for use with Marq-I only (6770031)
Cardiac Output Test: ■ Cardiac Output Cable Adapter (700092-001)

$Sp0_2$ Test: ■ Masimo and GE Ohmeda SpO_2 Simulator (408610-001 or equivalent) ◆ Masimo SpO_2 Simulator Cable (2006011-001 or equivalent) ◆ GE Ohmeda SpO_2 Simulator Cable (700232-004 or equivalent) ■ Nellcor Pulse Oximeter Tester Model SRC-2 (2007650-001) ◆ Dual BP Adapter Cable (2005772-001) ■ Nellcor OxiMax Pulse Oximeter Functional Tester Model SRC-MAX (2007650-002)
NBP Test: ■ NBP Cuff Coupling (400787-001) ■ NBP Hose Coupling (46100-002) ■ NBP Tee (4745-101) ■ NBP Tubing 2 feet (401582-001) ■ Manometer: digital or mercury (Meriam Instrument Smart Manometer Model 350 DM2000 or equivalent) ■ NBP Tube (414873-001) ■ NBP Cuff (9461-301) ■ Pipe: PVC
DEFIB Sync Test: ■ Oscilloscope
Transport Test: ■ Transport display with cable

General Test

1. Install the module in a Tram-rac housing.



2. Apply power to monitor by turning the rear panel power switch to the ON position.
3. Turn the display ON by pressing the **DISPLAY ON/OFF** or **POWER** key on the front panel of the monitor.
4. Make sure the power indicators on both the monitor and the Tram module are turned ON or illuminated green.
5. Connect the patient cable to module.
6. Attach appropriate leads to the simulator.

Parameter Tests

Select the appropriate tests to verify all parameters of the module under test. The parameter tests include:

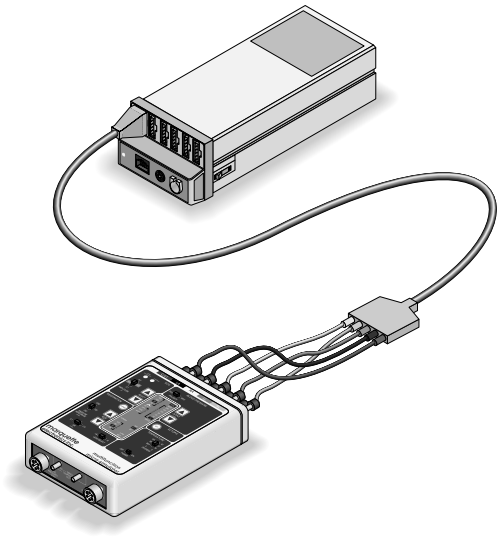
- ECG Test
- 12SL ECG Test
- Respiration Test
- BP Test
- Temperature Test
- CO Test
- SpO_2 Test
- NBP Test

NOTE
Test all parameters per module.

ECG Test

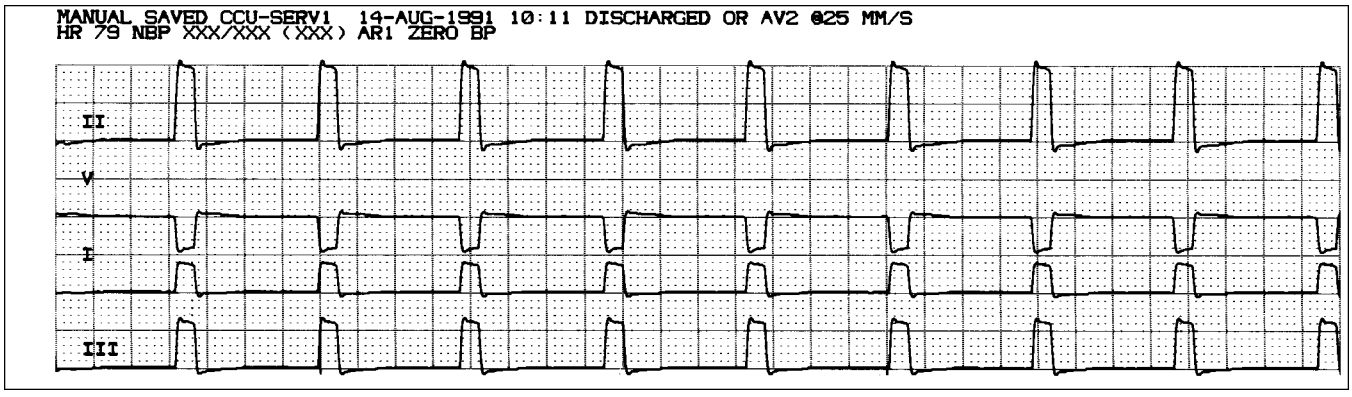
1. Set up the simulator:
   - Heart rate to 80 bpm.
   - ECG amplitude to 1.0 mV.

2. Attach a patient cable and leadwires between the ECG connector on the Tram module and the leadwire connectors on the top of the patient simulator.



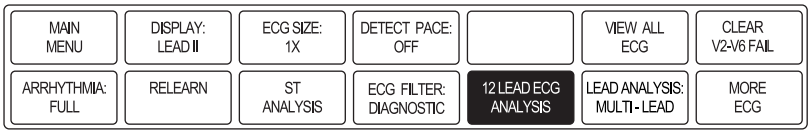
3. Admit a patient into system.

4. Make sure the following conditions are true:
   - The monitor displays ECG lead II, and it is noise-free.
   - The monitor displays an 80 ±1 bpm heart rate.
   - If the monitor has QRS tones are turned ON, an audible tone sounds with each QRS complex.
5. Make sure all seven ECG leads are available for display and are noise-free.
6. Set **DETECT PACE** to **NORMAL**.
7. Inject a VP2 pacemaker pulse with the simulator.
8. Observe following with leads II, III, aVR, aVF, and V:
   - On the monitor, a P appears above the PVC count to denote pacemaker mode.
   - The monitor still shows an 80 ±1 bpm heart rate.
9. Remove the pacemaker pulse input and return the simulator to these conditions:
   - Set heart rate to 80 bpm.
   - Set amplitude to 1.0 mV.
10. Select lead II for display in the top trace position.
11. Remove the RA leadwire from the patient cable.
12. Observe following:
    - The monitor displays an *RA FAIL* message.
    - The monitor displays lead III in place of lead II.
13. Replace the RA leadwire.
14. Inject a 1-millivolt calibration pulse with the simulator and start a manual graph.
15. Observe that the calibration pulses are properly displayed and graphed, as in the example below.



12SL ECG Test

1. At the monitor, go to the Main Menu.
2. Use the **Trim Knob** control to select the *ECG* parameter box.
3. At the *ECG* menu, select *12 LEAD ECG ANALYSIS*.



4. Make sure all 12 ECG traces are noise-free, and are displayed clearly.

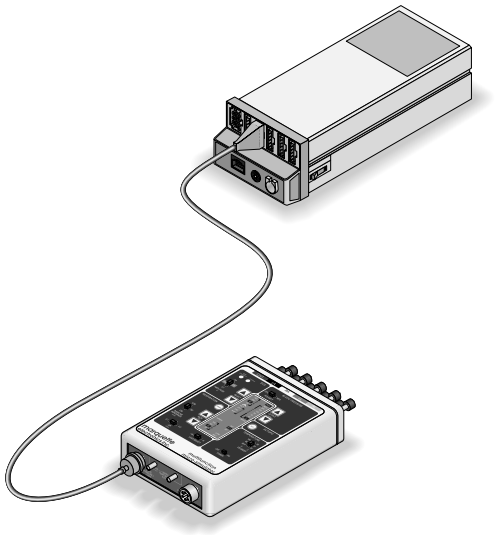
Respiration Test

1. Set up simulator:
   - Set baseline impedance to 750Ω (or 1000Ω if using Marq II).
   - Set ΔR to 0.5Ω.
   - Set lead select to I & II (or LL if using Marq II).
   - Set respiration rate to 30 breaths per minute.
2. Set up the monitor:
   - Turn the respiration waveform ON.
   - Set the respiration waveform to lead II.
3. Observe these conditions:
   - The monitor displays a distortion-free respiration waveform.
   - The monitor displays a respiration rate reading of 30 ±2 breaths per minute.
4. Set the respiration waveform to lead I at the monitor, LA at the simulator, and observe the same conditions as in step 3.

Blood Pressure Test

1. Set up simulator:
   - Set polarity to POS.
   - Set output to 0 mmHg.

2. Connect the BP simulator cable from the **BLOOD PRESSURE 1** connector of the simulator to the left most BP connector (**BP1**) of the Tram module.



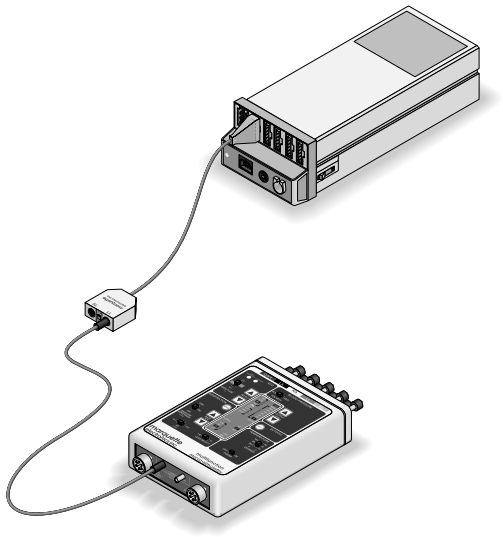
3. Observe an AR1 label and graticules on the monitor.
4. Zero the AR1 waveform.
5. Set the simulator to output 200 mmHg (240 if using Marq II).
6. Observe a reading of 200/200 (200) ± 4 mmHg (or 240 ± 4 mmHg if using Marq II) on the monitor.
7. Set the simulator to WAVE (or BP dynamic waveforms) output.
8. Set the BP scale on the monitor to auto.
9. Observe a distortion-free waveform and a blood pressure reading of approximately 120/80 (93) on the monitor.
10. Remove the cable from the **BP1** connector of the Tram module and insert it into the **BP2** connector. Repeat these tests with each BP connector.

NOTE

Use the Dual BP Adapter Cable to test the fourth BP connection.

Temperature Test

1. Set up the simulator for a 37°C temperature output.
2. Attach a temperature sensor adaptor to the TEMP/CO connector of the Tram module.



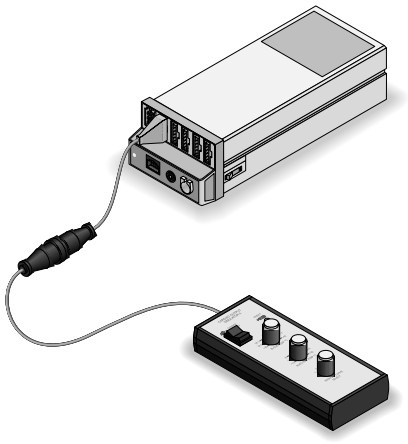
3. Set the switch on the adaptor to the 400 position.
4. Attach the temperature simulator cable from the **SERIES 400 TEMPERATURE OUTPUT** connector of simulator to the **T1** connector of the temperature sensor adaptor.
5. Observe that a **T1** reading appears on the display with reading between 36.6 and 37.4.
6. Move the cable from the **T1** connector of the temperature sensor adaptor to the **T2** connector.
7. Observe that a **T2** reading appears on the display with reading between 36.6 and 37.4.
8. Repeat the above procedure using 700 settings on simulator and cable.
9. Remove the temperature sensor adaptor and temperature cable from the Tram module and the simulator.

Cardiac Output Test

Cardiac output testing is different depending on the simulator you use. The Cardiac Output Simulator II is no longer available, but if you already have that simulator, use the first section to run this test. Otherwise, go to “Test with Marq II Simulator”.

Test with Cardiac Output Simulator II

1. Connect a cardiac output cable adapter to the **TEMP/CO** connector of the Tram module and connect the CO adaptor to a Cardiac Output Simulator II.



2. Set the cardiac output simulator to output the BT (blood temperature) readings in the following table and observe the correct readings on the monitor:

Simulator Output Blood Temperature Settings	
Simulator BT Setting	**Monitor BT Reading Range**
30.3°C	30.1 – 30.5
35.1°C	34.9 – 35.3
36.0°C	35.8 – 36.2
37.0°C	36.8 – 37.2
41.7°C	41.5 – 41.9

3. Set the cardiac output simulator to output the IT (injectate temperature) readings in the following table and observe the correct readings on the monitor:

Simulator Injectate Temperature Settings	
Simulator BT Setting	**Monitor BT Reading Range**
0.0°C	–0.3 – +0.3
8.0°C	7.7 – 8.3
15.0°C	14.7 – 15.3
24.0°C	23.7 – 24.3
29.6°C	29.3 – 29.9

Test with Marq II Simulator

1. Connect the cardiac output cable adapter to the TEMP/CO connector of the Tram module.
2. Connect the cardiac output adapter to the cardiac output cable adapter and to the Marq II simulator.
3. At the monitor, go to *MORE MENUS* ⇒ *CO*.
4. Set up the monitor:
   - Set *AUTO MODE:* to *ON*
   - Set *INJECT TEMP:* to *BATH*
   - Set *SIZE:* to 7
   - Set *INJECT VOL:* to *10CC*
   - Set *COMPUTATIONAL CONSTANT:* to *0.540*
5. Set the adapter to **0°**.
6. Turn the simulator **ON**. Select cardiac output menu corresponding to the injectate temperature. (i.e. menu #92 for 0°, or #95 for 24°)
7. When the monitor screen displays the message, *INJECT WHEN READY*, press **Enter** on the simulator.
8. When computing is complete, the CO reading should be approximately 37°C at 5 liters of blood per minute ± 5%.
9. Repeat this test with the adapter set to **24°** and the *COMPUTATIONAL CONSTANT:* set to 0.595.

   The output should be the same.

SpO_2 Test (Masimo)

NOTE
Do not connect the simulator to an AC power supply for these tests. Operate the simulator on battery power.

1. Turn the SpO_2 simulator power switch **OFF**.
2. Connect the simulator cable to the module.
3. Set the simulator as follows:

   NOTE
   Use the white-colored values on the simulator.

   - Set the MODE to **NELLCOR**.
   - Set the SpO_2% to **99**.
   - Set the PRR to **70** beats/minute.
   - Turn the power **ON**.

4. Verify the following are displayed at the monitor: (It might be necessary to turn the SpO_2 parameter on.)
   - A waveform with an SpO_2 label.
   - An SpO_2% reading between 97 - 100%.
   - A PRR reading between 67 and 72 beats per minute.
5. Test the accuracy of these SpO_2% settings.

SpO_2 Settings	
Simulator Setting	**Displayed Value**
99%	96 - 100%
90.6%	87 - 94%
80.3%	77 - 83%

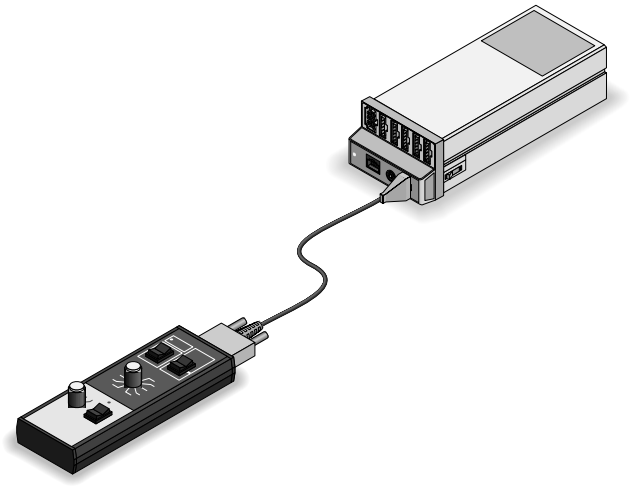
6. Test the accuracy of these PPR settings.

PPR Settings	
Simulator Setting	**Displayed Value**
70	67 – 73
100	97 – 103

7. Return the simulator to these conditions:
   - Set the SpO_2% to **99**.
   - Set the PPR to **70** beats/minute.
8. Set these alarms on the monitor:
   - Set SpO_2% LO to **90**.
   - Set PPR HI to **90**.
9. Set PPR on the simulator to **100**.
10. Make sure the PPR value on the monitor flashes, and it sounds an alarm.
11. Return PPR on the simulator to **70**.
12. Set SpO_2% on the simulator to **80.3**.
13. Make sure the SpO_2% value on the monitor flashes, and it sounds an alarm.
14. Disconnect the simulator cable from the module.

SpO_2 Test (GE)

1. Turn the SpO_2 simulator power switch **OFF**.
2. Connect the simulator to the Tram module simulator cable.



3. Set the simulator as follows:
   - Set the **MODE** to **NELLCOR**.
   - Set the SpO_2% to **99**.
   - Set the PRR to **100** beats/min.
   - Turn the power **ON**.
4. Verify that the following are displayed at the monitor:
   - A sinusoidal waveform with an SpO_2 label.
   - An SpO_2% reading between 97 – 100% (97 and 102%).
   - A PRR reading between 97 and 103 beats per minute (it might be necessary to turn the SpO_2 ON).
5. Test the accuracy of these SPO_2% settings.

Accuracy of SpO_2 Settings	
Simulator Setting	**Displayed SpO_2 Value**
99% (Both types)	97 – 100% (97 – 102%)
80.3% (84%)	78 – 82% (81 – 87%)
49.7 (63%)	48 – 52% (61 – 65%)

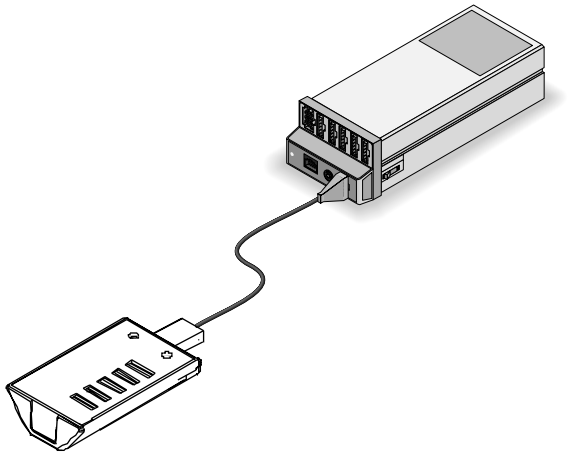
6. Test the accuracy of these PPR settings:

Accuracy of PPR Settings	
Simulator Setting	**Displayed PPR Value**
70	68 – 72
100	97 – 103
160	156 – 164

7. Return the simulator to these conditions:
   - Set the SpO_2% to **99**.
   - Set the PPR to **100** beats/min.
8. Press the **NOISE TEST** button **ON** the simulator for 30 seconds.
9. Make sure the monitor still displays an SpO_2 value between 97 and 100% (97 and 102%), or an interference detection message is displayed.
10. Set these alarms on the monitor:
    - Set SpO_2% LO to **90**.
    - Set PPR HI to **150**.
11. Set PPR on the simulator to **160**.
12. Make sure the PPR value on the monitor flashes, and it sounds an alarm.
13. Return PPR on the simulator to **100**.
14. Set SpO_2% on the simulator to **80.3%** (84%).
15. Make sure the SpO_2% value on the monitor flashes, and it sounds an alarm.
16. Turn the simulator **OFF**.
17. Make sure the monitor shows a *CHECK PROBE* message.
18. Disconnect the simulator cable from the Tram module.

SpO_2 Test (Nellcor OxiSmart)

1. Connect the Nellcor Pulse Oximeter SRC-2 to the sensor connector.



2. Make sure that the SRC-2 **IR** and **RED** LED drive indicators are both lit.
3. Set the **RCAL/MODE** switch to **RCAL 63/LOCAL**.
4. Set the **LIGHT** and **MODULATION** switches as follows:
   - Set the **LIGHT** switch to **HIGH 1**.
   - Set the **MODULATION** switch to **HIGH**.
   - Set the **RATE** switch to **112**.

   Allow the Tram a few seconds to obtain a steady reading.
5. Verify the following SpO2 readings for saturation and pulse rate:
   - Saturation (%): 81 ±2
   - Rate (bpm): 112 ±2% (110 to 114)
6. Set the **LIGHT** and **MODULATION** switches as follows:
   - Set the **LIGHT** switch to **LOW**.
   - Set the **MODULATION** switch to **LOW**.
   - Set the **RATE** switch to **201**.
7. Verify the following SpO2 readings for saturation and pulse rate:
   - Saturation (%): 81 ±2
   - Rate (bpm): 201 ±3% (195 to 207)
8. Set the **LIGHT** and **MODULATION** switches as follows:
   - Set the **LIGHT** switch to **HIGH 2**.
   - Set the **MODULATION** switch to **LOW**.
   - Set the **RATE** switch to **38**.

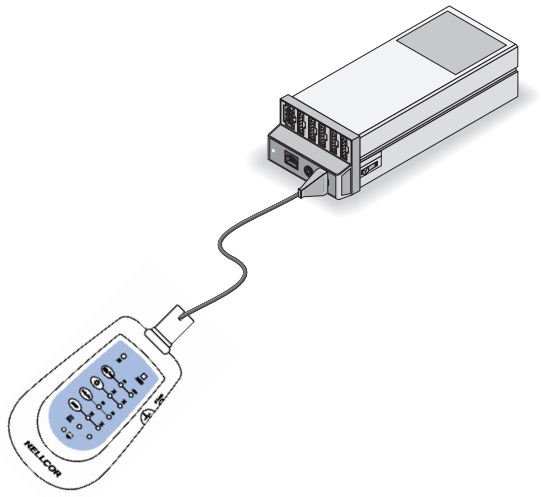
9. Verify the following SpO2 readings for saturation and pulse rate:
   - Saturation (%): 81 ±2
   - Rate (bpm): 38 ±2% (37 to 39)

10. Set the **LIGHT** and **MODULATION** switches as follows:
    - Set the **LIGHT** switch to **LOW**.
    - Set the **MODULATION** switch to **HIGH**.
    - Set the **RATE** switch to **201**.

11. Verify the following SpO2 readings for saturation and pulse rate:
    - Saturation (%): 81 ±2
    - Rate (bpm): 201 ±3% (195 to 207)

SpO_2 Test (Nellcor OxiMax)

1. Verify that 2 AA alkaline batteries are installed in the SRC-MAX Nellcor Pulse Oximetry functional tester.
2. Connect the Nellcor Pulse Oximeter SRC-MAX to the sensor connector.



3. Verify that the SRC-MAX **IR** and **RED** LED drive indicators are both lit on the SRC-MAX.
4. Verify the SRC-MAX default indicators are set as follows:
   - HEART RATE = 60 bpm
   - LIGHT = LOW
   - %SpO2 = 75
   - MODULATION = LOW

   Allow the Tram a few seconds to obtain a steady reading.

5. Verify the following SpO2 readings for saturation and pulse rate:
   - Saturation (%): 75 ±2
   - Rate (bpm): 60 ± 2

6. Press and release the **HEART RATE** switch and verify the SRC-MAX default indicators are lit as follows:
   - HEART RATE = 200 bpm
   - LIGHT = LOW
   - %SpO2 = 75
   - MODULATION = LOW

   Allow the Tram a few seconds to obtain a steady reading.

7. Verify the following SpO2 readings for saturation and pulse rate:
   - Saturation (%): 75 ±2
   - Rate (bpm): 200 ±3% (194 to 206)

8. Press and release the **LIGHT** switch and verify the SRC-MAX default indicators are lit as follows:
   - HEART RATE = 200 bpm
   - LIGHT = HIGH
   - %SpO2 = 75
   - MODULATION = LOW

   Allow the Tram a few seconds to obtain a steady reading.

9. Verify the following SpO2 readings for saturation and pulse rate:
   - -Saturation (%): 75 ±2
   - -Rate (bpm): 200 ±3% (194 to 206)

10. Press and release the %SpO2 switch and verify the SRC-MAX default indicators are lit as follows:
    - HEART RATE = 200 bpm
    - LIGHT = HIGH
    - %SpO2 = 90
    - MODULATION = LOW

    Allow the Tram a few seconds to obtain a steady reading.

11. Verify the following SpO2 readings for saturation and pulse rate:
    - Saturation (%): 90 ±2
    - Rate (bpm): 200 ±3% (194 to 206)

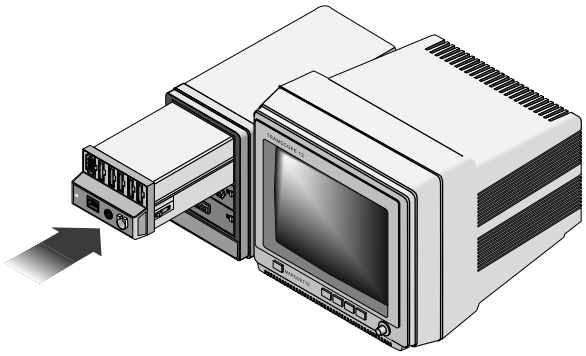
12. Press and release the **MODULATION** switch and verify the SRC-MAX default indicators are lit as follows:
    - HEART RATE = 200 bpm
    - LIGHT = HIGH
    - %SpO2 = 90
    - MODULATION = HIGH

    Allow the Tram a few seconds to obtain a steady reading.

13. Verify the following SpO2 readings for saturation and pulse rate:
    - Saturation (%): 90 ±2
    - Rate (bpm): 200 ±3% (194 to 206)

NBP Tests

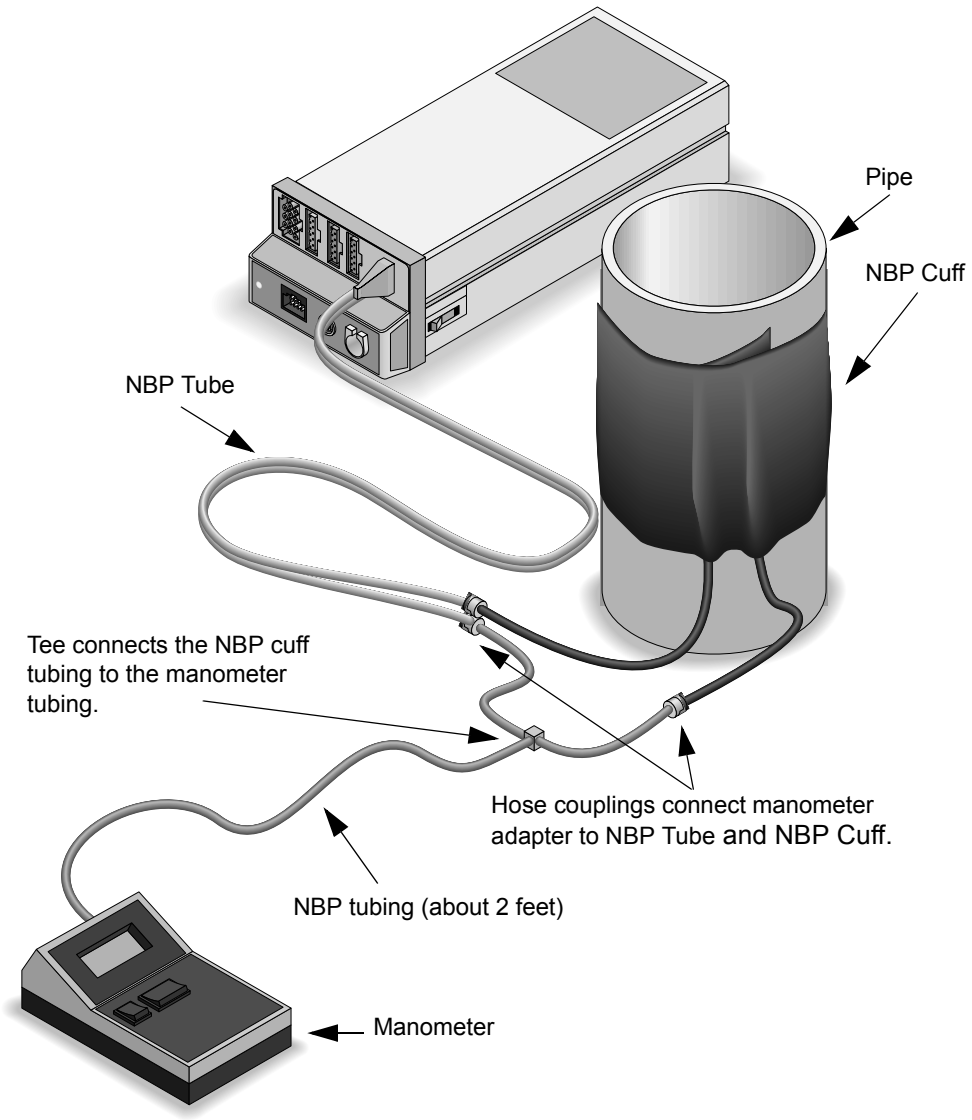
1. Insert the module in the top slot of a Tram-rac housing.



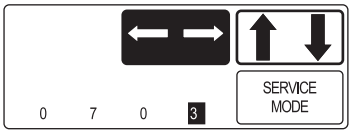
2. Disconnect all parameter cables.
3. Apply power to the monitor. If your Tram-rac housing has its own power supply, apply power.
4. Make sure the POWER indicator on the Tram module's front panel is turned ON.

WARNING
When the NBP cuff is used in this procedure, it must be tightly wrapped around a tube. DO NOT place the cuff around your arm during the calibration procedures.

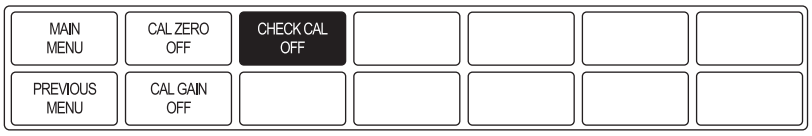
5. Connect a manometer and NBP cuff to the NBP connector on the front of the Tram module as shown.


Pipe
NBP Cuff
NBP Tube
Tee connects the NBP cuff tubing to the manometer tubing.
Hose couplings connect manometer adapter to NBP Tube and NBP Cuff.
NBP tubing (about 2 feet)
Manometer

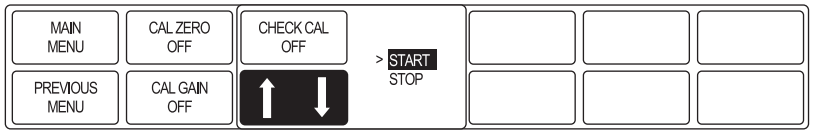
6. Turn the manometer ON, and set its range switch to the 1000 mmHg setting.
7. From the monitor's main menu, select *MONITOR SETUP*.
8. Select *SERVICE MODE*.
9. Enter the password to get into the service mode. The first two digits of the password are the day of the month, and the second two digits are the month. For example, on 7 March, the password would be 0703.
10. Select *SERVICE MODE*.



11. Select *CALIBRATE NBP*.
12. Select *CHECK CAL OFF*.



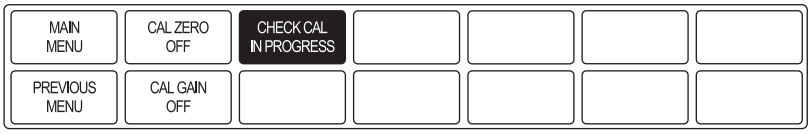
13. Select *START*.



14. The text on the menu item changes from *CHECK CAL OFF* to *CHECK CAL IN PROGRESS*. Make sure that the pressure readings (shown as *CUFF* in the *NBP* parameter box) on the monitor display and manometer are equal (± 1 mmHg) for at least one full minute.

    If they are not equal, calibrate the NBP parameter according to procedures in "NBP Calibration" on page 4-11.

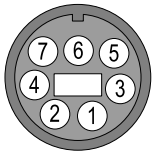
15. Select *CHECK CAL IN PROGRESS*.



16. Select *STOP*. The module then releases pressure in the bulb or cuff.
17. Remove the cuff and manometer from the Tram module.

DEFIB SYNC Test

1. Connect an oscilloscope to the **DEFIB SYNC** connector on the front panel of the Tram module.
2. Test the ECG, Arterial BP, and Marker Out signals from the **DEFIB SYNC** connector. They should resemble the waveforms in the following figure. Note that there are two Marker Out traces shown. The top trace shows the frequency of the pulses; the bottom trace shows the pulse width.

Defibrillator Synchronization connector J2			
Pin	**Name**	**Descriptions**	
1	DEFIB_MARKER_OUT	Digital defibrillator output synchronization signal	 **Front View of Module**
2	DEFIB_MARKER_IN	Digital defibrillator input signal	
3	AGND1	Signal Ground	
4	DGND	Signal Ground	
5	AGND2	Signal Ground	
6	BP_ANALOG_OUTPUT	Analog BP/OUTPUT	
7	ECG_ANALOG_OUTPUT	Analog ECG output signal	

ECG

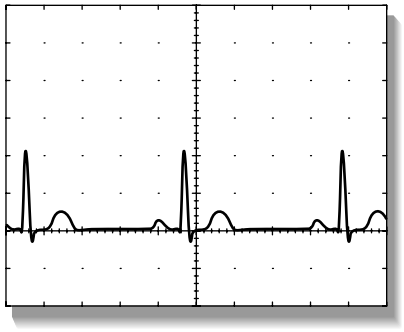
Signal Pin: **7**

Ground Pin: **3**

Probe Type: **x10**

Time/Division: **0.2S**

Volts/Division: **0.5V**



023A

Arterial BP

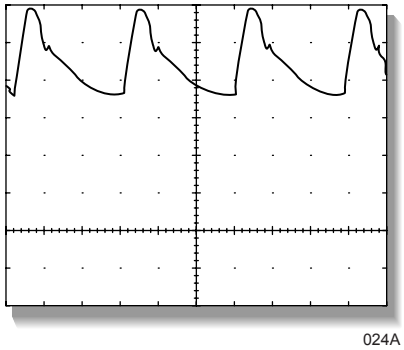
Signal Pin: **6**

Ground Pin: **5**

Probe Type: **x10**

Time/Division: **0.2S**

Volts/Division: **0.2V**



024A

NOTE

The Marker Out amplitude and pulse width are configured at 5V and 10ms respectively from the factory. To change these settings refer to "Module Processor PCB" on page 4-5.

Marker Out (Frequency)

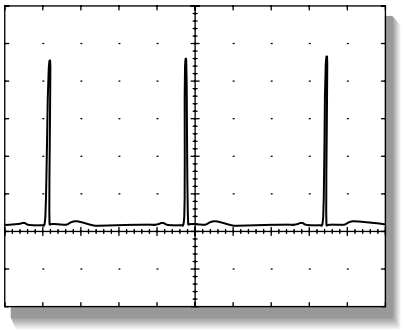
Signal Pin: **1**

Ground Pin: **4**

Probe Type: **x10**

Time/Division: **0.2S**

Volts/Division: **1V**



025A

Marker Out (Pulse Width)

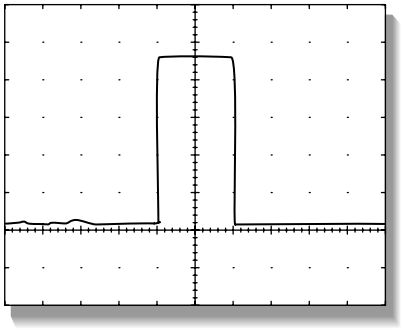
Signal Pin: **1**

Ground Pin: **4**

Probe Type: **x10**

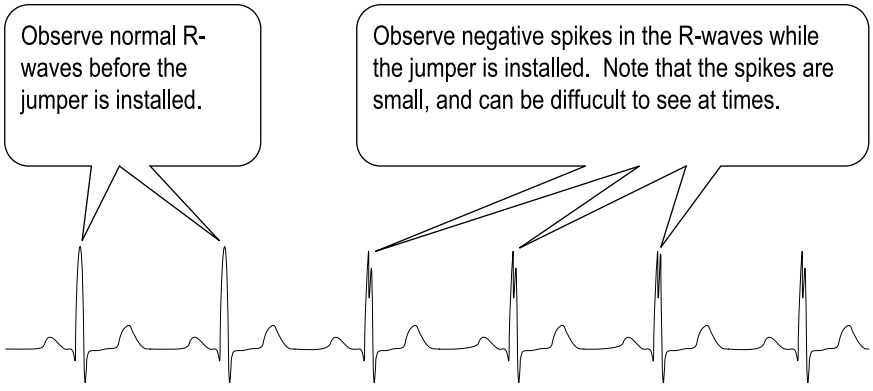
Time/Division: **5mS**

Volts/Division: **1V**



026A

3. Attach a jumper between pin 1 (Marker Out) and pin 2 (Marker In) of the **DEFIB SYNC** connector and observe negative spikes in the R-waves of the displayed ECG waveforms.


Observe normal R-waves before the jumper is installed.
Observe negative spikes in the R-waves while the jumper is installed. Note that the spikes are small, and can be diffucult to see at times.

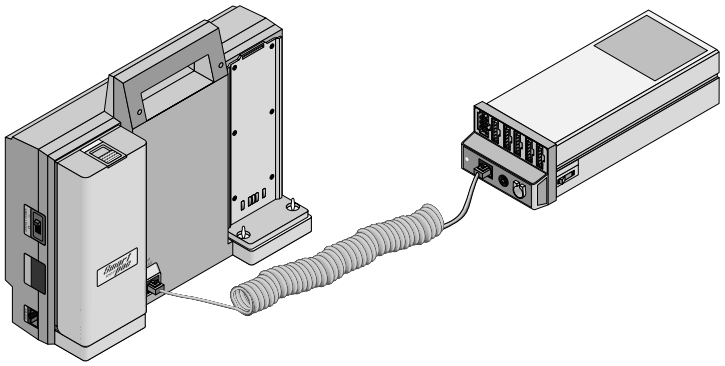
4. Remove the jumper.

Fan Test

Listen for the fan. The fan should be running whenever the Tram module is installed in a bedside monitor.

Transport Test

1. Connect the Tram module to a transport display. Make sure there are batteries on the rear of the display, and that the batteries are sufficiently charged.



2. Remove the Tram module from the Tram-rac.
3. Set up simulator:
   - Set heart rate to 80 bpm.
   - Set amplitude to 1.0 mV.
4. Observe the following:
   - No error messages show on the transport display.
   - The transport display shows ECG lead II, and it is noise-free.
   - The transport display shows a heart rate of 80 ±1 bpm.
   - If the QRS tones are turned ON, an audible tone sounds with each QRS complex.
5. Make sure that you can display all of the available ECG leads.

Completion

1. Turn all test equipment OFF.
2. Remove all test cabling from the Tram module.

Electrical Safety Tests

General

Electrical safety tests provide a method of determining if potential electrical health hazards to the patient or operator of the device exist.

Recommendations

GE Medical Systems *Information Technologies* recommends that you perform all safety tests presented in this chapter.

- upon receipt of the device (monitor and its associated equipment),
- every twelve months thereafter,
- each time the main enclosure is disassembled or a circuit board is removed, tested, repaired, or replaced, and
- record the date and results on the "Maintenance/Repair Log" included at the end of this chapter.

These instructions are intended for every component in the system. If the Tram-rac housing does not have its own power supply, it should remain connected to the monitor throughout the safety tests.

WARNING
Failure to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards. Unless you have an Equipment Maintenance Contract, GE Medical Systems *Information Technologies* does not in any manner assume the responsibility for performing the recommended maintenance procedures. The sole responsibility rests with the individual or institution using the equipment. GE Medical Systems *Information Technologies* service personnel may, at their discretion, follow the procedures provided in this manual as a guide during visits to the equipment site.

Test Conditions

Electrical safety tests may be performed under normal ambient conditions of temperature, humidity, and pressure.

Test Equipment

The recommended test equipment required to perform electrical safety tests is listed below.

Item	Specification
Leakage Current Tester	Equivalent to the circuits shown
Digital Multimeter (DMM)	AC volts, ohms
Ground Bond Tester, if test required	0 – 1 ohm
ECG Test Body	MT-3387
Masimo $Sp0_2$ Test Body	2006036-001
GE Ohmeda and Nellcor $Sp0_2$ Test Body	2006646-001

Power Outlet Test

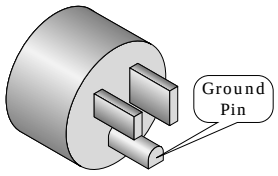
Before starting the tests, the power outlet from which the monitoring device will get electrical power must be checked. This test checks the condition of the power outlet to ensure correct results from leakage tests.

For international power outlets, refer to the internal standards agencies of that particular country. Use a digital multimeter to ensure the power outlet is wired properly.

If other than normal polarity and ground is indicated, corrective action must be taken before proceeding. The results of the following tests will be meaningless unless a properly wired power outlet is used.

Ground (Earth) Integrity

Listed below are two methods for checking the ground (earth) integrity, “Ground Continuity Test” and “Impedance of Protective Earth Connection.” These tests determine whether the device's exposed metal and power inlet's earth (ground) connection has a power ground fault condition.



Perform the test method below that is required by your Country/Local governing safety organization.

Ground Continuity Test

Completion of this test is checked by the following steps:

1. Disconnect the device under test from the power outlet.
2. Connect the negative (-) lead of the DMM to the protective earth terminal (ground pin in power inlet connector) or the protective earth pin in the Mains plug (ground pin in power cord). Refer to the US 120Vac power cord figure above.
3. Set the DMM to the milliohm (mΩ) range.
4. Connect the positive (+) lead of the DMM to all exposed metal surfaces on the device under test. If the metal surfaces are anodized or painted, scrape off a small area in a inconspicuous place for the probe to make contact with the metal.
5. Resistance must read:
   - 0.1 ohm or less without power cord
   - 0.2 ohms or less with power cord

Impedance of Protective Earth Connection

This test unlike a ground continuity test will also stress the ground system by using special ground bond testers.

This test normally is only required as a manufacturing production test to receive safety agency compliance (i.e. IEC601-1).

Some country agency's do require this test after field equipment repairs (i.e. Germany's DIN VDE 0751 standards).

Consult your country/local safety agency if in question.

Compliance is checked by the following steps:

1. A current not less than 10A and not exceeding 25A from a current source with a frequency of 50 or 60 Hz with a no-load voltage not exceeding 6 V is passed for at least 5 s through the protective earth terminal or the protective earth pin in the mains plug and each accessible metal part which could become live in case of failure in basic insulation.
2. The voltage drop between the parts described is measured and the impedance determined from the current and voltage drop. It shall not exceed the values indicated.

For equipment without a power supply cord the impedance between the protective earth terminal and any accessible metal part which is protectively earthed shall not exceed 0.1 ohms

For equipment with a power supply cord the impedance between the protective earth pin in the mains plug and any accessible metal part which is protectively earthed shall not exceed 0.2 ohms.

When taking this measurement, move the unit's power cord around. There should be no fluctuations in resistance.

Ground (Earth) Wire Leakage Current Tests

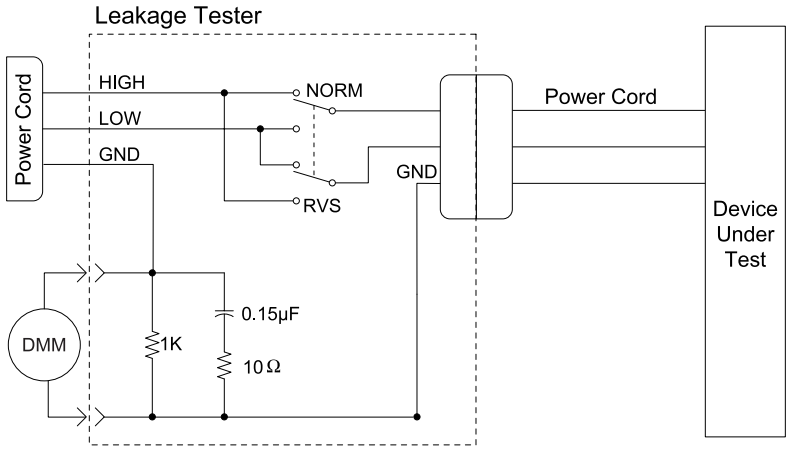
Perform this test to measure current leakage through the ground (earth) wire of the equipment during normal operation.

NOTE

The DMM plus leakage tester network shown is the circuitry defined by the UL 544 standard for measuring leakage current.

The measuring devices, defined by various standard organizations (IEC, UL, etc.), produce almost identical test measurement results.

1. Configure the leakage tester like the circuit shown below.



DMM set to measure AC voltage

2. Connect the power cord of the device under test to the power receptacle on the leakage tester.
3. The device under test is to be tested at its normal operating voltage.
4. Set the power switch of the device under test to ON.
5. Read the current leakage indicated on DMM.
6. Set the polarity switch on the leakage tester to RVS (reverse).
7. Read the current leakage indicated on DMM.

NOTE

If either reading is greater than the appropriate specification below, the device under test fails. Contact GE Medical Systems *Information Technologies* Technical Support.

- 300 µA (0.3 volts on the DMM), and the device under test is powered from 100-120 V/50-60 Hz
- 300 µA (0.3 volts on the DMM), and the device under test is powered from a centered-tapped 200-240 V/50-60 Hz, single phase circuit
- 500 µA (0.5 volts on the DMM), and the device under test is powered from a non-center-tapped, 200-240 V/50-60 Hz, single-phase circuit

NOTE

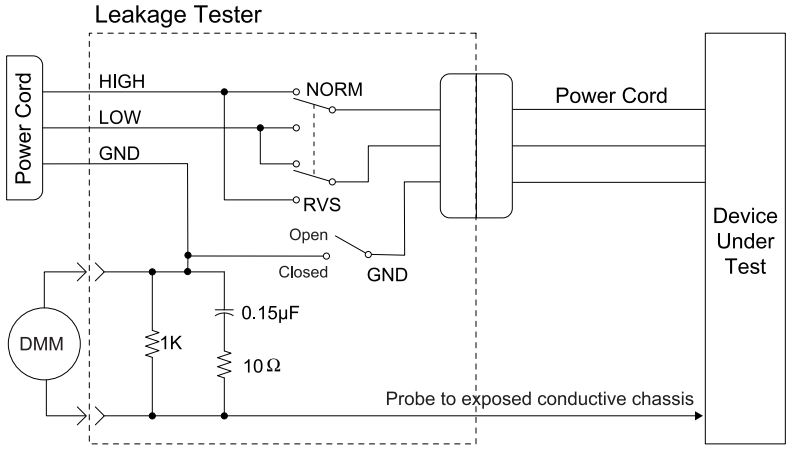
Center-tapped and non-center-tapped supply circuits produce different leakage currents and the UL and IEC limits are different.

8. Set the power switch of the device under test to OFF.

Enclosure Leakage Current Test

Perform this test to measure current leakage through exposed conductive surfaces on the device under test during normal operation.

1. Configure the leakage tester like the circuit shown below with GND switch OPEN and polarity switch NORM.



DMM set to measure AC voltage

2. Connect probe to an unpainted, non-anodized chassis ground on the unit under test.
3. Set the power switch of the device to ON.
4. Read the current leakage indicated on DMM.

NOTE

Center-tapped and non-center-tapped supply circuits produce different leakage currents and the UL and IEC limits are different.

5. Set the polarity switch to RVS.
6. Read the current leakage indicated on DMM.

NOTE

If either reading is greater than the appropriate specification below, the device under test fails. Contact GE Medical Systems *Information Technologies* Technical Support.

- 300 µA (0.3 volts on the DMM), and the device under test is powered from 100-120 V/50-60 Hz
- 300 µA (0.3 volts on the DMM), and the device under test is powered from a centered-tapped 200-240 V/50-60 Hz, single phase circuit

- 500 µA (0.5 volts on the DMM), and the device under test is powered from a non-center-tapped, 200-240 V/50-60 Hz, single-phase circuit

7. Set the GND switch on the leakage tester to CLOSED.
8. Read the current leakage indicated on DMM.
9. Set the polarity switch to RVS.
10. Read the current leakage indicated on DMM.

NOTE

If the reading is greater than the specification below, and the device under test is powered from 100-240 V/50-60 Hz, the device under test fails. Contact GE Medical Systems *Information Technologies* Technical Support.

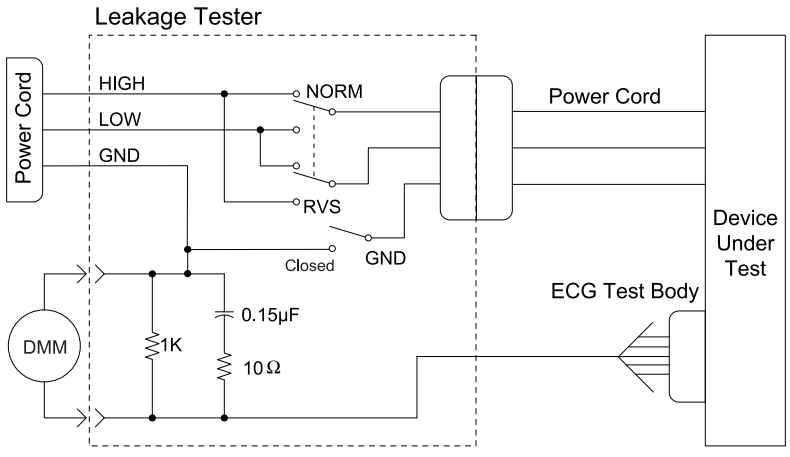
- 100 µA (0.1 volts on the DMM), and the device under test is powered from 100-240 V/50-60 Hz

11. Set the power switch of the device under test to OFF.

Patient (Source) Leakage Current Test

This procedure measures the leakage current from the ECG/RESP connector of the device to ground.

1. Configure the leakage tester like the circuit shown below with GND switch OPEN and polarity switch NORM.



DMM set to measure AC voltage

2. Connect an ECG test body to the ECG/RESP connector of the device under test.
3. Set the power switch of the device to ON.
4. Read the leakage current indicated on the DMM.
5. Change the leakage tester polarity switch to the RVS position.
6. Read the leakage current indicated on the DMM.

NOTE

If either reading is greater than 50 µA (0.05 volts on the DMM), the device fails this test. Contact GE Medical Systems *Information Technologies* Technical Support.

7. Change the GND switch to the Closed position.
8. Read the leakage current indicated on the DMM.
9. Change the leakage current switch to the RVS position.
10. Read the leakage current indicated on the DMM.

NOTE

If either reading is greater than 10 µA (0.01 volts on the DMM), the device fails this test. Contact GE Medical Systems *Information Technologies* Technical Support.

11. For Tram modules X51M, repeat the above steps with Masimo SpO_2 Test Body. For Tram modules X51 or X51N, repeat the above steps with GE Ohmeda and Nellcor SpO_2 Test Body.
12. Set the power switch of the device to OFF.

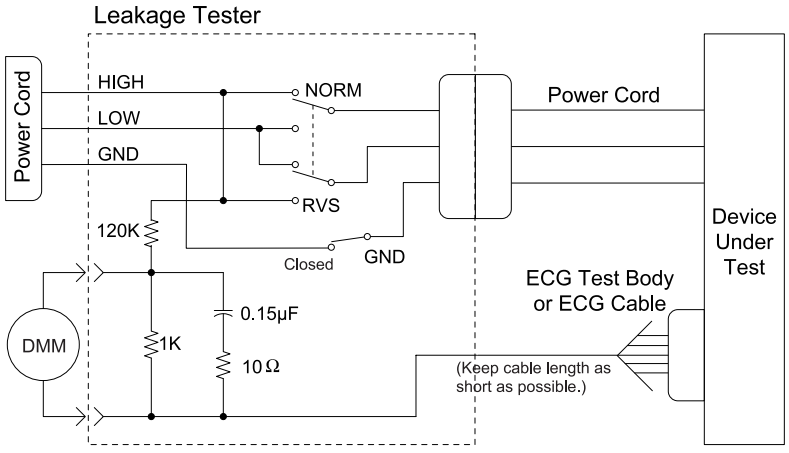
NOTE

The AAMI and IEC single fault condition (ground open) is 50 µA, whereas the normal condition (ground closed) is less.

Patient (Sink) Leakage Current Test
(Mains Voltage on the Applied Part)

This procedure measures the leakage current from a mains voltage source into the ECG/RESP connector.

1. Configure the leakage tester like the circuit shown below with GND switch CLOSED and polarity switch NORM.



DMM set to measure AC voltage

WARNING
Shock hazard. The following step causes high voltage at the test body. Do not touch the test body.

2. Set power switch on the device to ON.
3. Read leakage current indicated on DMM.
4. Change the leakage tester polarity switch to the RVS position.
5. Read the leakage current indicated on the DMM.

NOTE
If either reading is greater than the appropriate specification below, the device under test fails. Contact GE Medical Systems *Information Technologies* Technical Support.

- 10 µA (0.01 volts on the DMM) at 120 VAC using the test body.
- 20 µA (0.02 volts on the DMM) at 240 VAC using the test body.
- 50 µA (0.05 volts on the DMM) at 120-240 VAC using the ECG cable.

NOTE
The 10 and 20 µA limits are based on internal design standards. The 50 µA limit is common to all standards. AAMI ES-1 standard requires using the patient cable.

6. For Tram modules X51M, repeat the above steps with Masimo SpO_2 Test Body. For Tram modules X51 or X51N, repeat the above steps with GE Ohmeda and Nellcor SpO_2 Test Body.
7. Set the power switch on the device to OFF.

Test Completion

1. Disconnect the leakage tester from the power outlet.
2. Disconnect all test equipment from the device.
3. Disconnect the device power cord from the leakage tester.

AC Hi-Pot Test

Hi-pot (high-potential) tests are performed on the patient connected data acquisition assembly to ensure patient isolation from possible electrical safety hazards. It also ensures that the energy from a defibrillator is delivered to the patient and does not arc to ground.

Test Frequency

Hi-pot tests are required only if an isolated DAS module is opened for repair.

WARNING
Failure to perform hi-pot tests may cause undue equipment failure and possible health hazards. GE Medical Systems *Information Technologies* does not in any manner, unless an Equipment Maintenance Contract exists, assume the responsibility for performing this recommended health test. The sole responsibility rests with the individual or institution using the equipment.

Required Tools/Equipment

Equipment required to perform the test is listed below. Equivalent equipment may be substituted.

Required Tools/Equipment	
Item	**Specifications or Part Number**
AC Hi-Pot Generator	0 - 5000 Vac
ECG Test Body	MT-3387
Tram Hi-pot Cable	97516-101
Masimo $Sp0_2$ Test Body	2006036-001, if required
GE Ohmeda and Nellcor $Sp0_2$ Test Body	2006646-001, if required

AC Hi-Pot Generator Setup

1. Set the VOLTAGE RANGE to attain 4000 Vac.
2. Set the RAISE VOLTAGE selector to 0 volts.
3. Set the CURRENT LIMIT trip point to 1mA.
4. If generator has an automatic timer, set it for 10 seconds.

Procedures

WARNING
Shock hazard. DO NOT perform this test on any other connectors.

1. Connect all ground pins at the rear panel connector on the module to the GROUND of the AC/DC hi-pot generator using the hi-pot cable.
2. Install the ECG test body in the ECG connector of the module.
3. Connect the hi-pot generator output lead to the exposed lead of the test body.

WARNING
Shock hazard. Notify all personnel in the area that this high voltage test is being performed.

4. Turn the hi-pot generator power switch to **ON**.
5. Set the HIGH VOLTAGE switch to **ON**.
6. Slowly increase output voltage to 4000 volts.
7. Wait for 10 seconds. There should be no indication of breakdown (warning lamp or buzzer).
8. Turn off the hi-pot tester and disconnect the leads.
9. For modules with SpO_2, repeat these steps using the appropriate SpO_2 test body.
10. If your module fails this test, contact GE Medical Systems *Information Technologies* Tech Support.

Software Updates

Software downloading procedures are provided with each software upgrade kit.

Note all internal software revisions of the Tram module and host monitors. To find out if new software is available, call GE Medical Systems *Information Technologies* Tech Support.

Maintenance Checklist

Use the following checklist to ensure maintenance completion.

"Visual Inspection" on page 5-4

1. ____ Case
2. ____ Cables and Connectors

"Exterior Cleaning" on page 5-4 ___

"Checkout Procedure" on page 5-5

1. ____ General
2. ____ Parameter Tests
   - ____ ECG
   - ____ 12SL ECG
   - ____ Respiration
   - ____ Blood Pressure
   - ____ Temperature
   - ____ Cardiac Output
   - ____ SpO_2
3. ____ DEFIB SYNC Test
4. ____ Fan Test
5. ____ Transport Test

"Electrical Safety Tests" on page 5-26

1. ____ Power Outlet Test
2. ____ Ground (Earth) Integrity
3. ____ Ground (Earth) Wire Leakage Current Tests
4. ____ Enclosure Leakage Current Test
5. ____ Patient (Source) Leakage Current Test
6. ____ Patient (Sink) Leakage Current Test

"AC Hi-Pot Test" on page 5-34 ___

Repair Log

Unit Serial Number:
Institution Name:

Date	Maintenance/Repair	Technician

6 Troubleshooting

For your notes

Visual Inspection

A thorough visual inspection of the equipment can save time. Small things—disconnected cables, foreign debris on circuit boards, missing hardware, loose components—can frequently cause symptoms and equipment failures that may appear to be unrelated and difficult to track.

Take the time to make all the recommended visual checks (refer to the visual inspection chart) before starting any detailed troubleshooting procedures.

Visual Inspection List	
Area	**Look for the following problems:**
I/O Connectors and Cables	Fraying or other damage Bent prongs or pins Cracked housing Loose screws in plugs
Interface Cables	Excessive tension or wear Loose connection Strain reliefs out of place
Circuit Boards	Moisture, dust, or debris (top and bottom) Loose or missing components Burn damage or smell of over-heated components Socketed components not firmly seated Solder problems: cracks, splashes on board, incomplete feedthrough, prior modifications or repairs
Ground Wires/Wiring	Loose wires Faulty wiring Wires pinched or in vulnerable position
Mounting Hardware	Loose or missing screws or other hardware
Power Source	Faulty connection between PCBs Power source problems may cause static discharge, resetting problems, and noise.

NOTE

Hi pot testing is recommended if ISO assembly is open. For more information see Chapter 5, Maintenance.

CAUTION

Solder multilayer and surface mount PCB assemblies at your own risk! Improper repair methods can damage the PCB assemblies even further. Only qualified service personnel with the proper laboratory equipment should attempt to repair PCB assemblies.

Troubleshooting Procedure

To use this troubleshooting procedure, read through the problem column in the table until you find a similar problem to the one you are having. Do not perform any invasive procedures listed in this procedures unless you are a trained field or bio-medical engineer.

CAUTION
This procedure is intended for use by service personnel with advanced troubleshooting skills. The consequences of the following steps may cause loss of patient data and disruption of the entire Unity Network.

Problem	Cause/Information	Solution
The power indicator does not turn on.	If the power indicator fails to turn on and the monitor has no communications with the Tram module, it means that power isn't getting from the monitor to the module processor PCB.	1. Verify that the monitor is functional. 2. Frequently, a failure of this sort is caused by a faulty power supply PCB. Replace power supply PCB.
The diagnostic indicator does not turn on.	The Tram module has one diagnostic indicator, dual-color light-emitting diode DS1, located on the bottom of the module processor PCB. It is referred to as the "I AM OK" light.	Follow these steps to check the indicator. 1. Remove the module cover. 2. Turn the Tram module upside down. 3. Apply power to the Tram module. The easiest way to do this is to connect a Smart-pac-equipped transport display to the front panel connector of the Tram module. Another method is to use an extender board connected to a monitor. 4. The diagnostic indicator is visible between the power supply PCB and the bottom chassis ground plate. Watch it when applying power. If the Tram module is operational the indicator ■ glows red until the communication controller on the module processor is running, ■ flashes between green and red a couple of times while the main microprocessor on the module processor PCB boots, and then ■ steadily glows green until external power is removed.
The diagnostic indicator never flashes at all when the power is applied.		Replace the module processor PCB.
The diagnostic indicator stays steady red.		1. Disconnect the pulse oximetry PCB and power the module again. If this does not work, then 2. Replace the module processor PCB.

Problem	Cause/Information	Solution
The fan does not turn on.	When inserted into a Tram-rac, the module tries to establish communication with the monitor.	Turn the fan ON after the module is connected to a transport display. If the diagnostic indicator continues to flash between red and green and ■ the fan doesn't turn on, then replace the module processor pcb. ■ the fan does turn on, then replace the data acquisition module.
The Tram Module does not communicate with the monitor or display.	When the Tram module doesn't communicate with a transport display, the transport display shows a *COMMUNICATION FAILURE* message. With the Tram module inserted in a Tram-rac, view the software revisions at the monitor. If the Tram module software revision isn't listed, the Tram module isn't communicating with the monitor.	If the Tram module communicates with a monitor, but not a transport display ■ make sure the Tram module is plugged into the connector at the rear of the transport display, ■ test continuity on the flex circuit or swap the assemblies. Replace the non-isolated input PCB, or the flex circuit that connects it to the module processor PCB. ■ swap the module processor PC. If the Tram module communicates with a transport display, but not a monitor ■ replace the power supply PCB, or ■ swap the module processor PCB. If the Tram module doesn't communicate with either the transport display or the monitor, replace the module processor PCB.
CALL SERVICE 208 **message displays**	Tram module RAM battery voltage low.	Replace battery BT1 on the module processor PCB.
BATTERY FAIL **message displays**	Smart-pac battery pack failure.	Charge the Smart-pac battery pack in a Smart-pac charger.

Service Messages -Transport Display

When active, service messages usually display in the upper left corner of the screen on the transport display. The exception to this is *BATTERY FAIL*, which displays in the center of the screen on the transport display.

The following table lists the possible service messages that may appear when using a transport display with one of the Tram modules, and what they mean.

List of Service Messages	
Message	**Description**
CALL SERVICE 25	Bus error occurred.
CALL SERVICE XX	Task Stack Overflow Error. If XX<25, then XX is the number of a Tram module task for the stack overflow. If XXŠ50, then XX-49 is the number of a transport display task for the stack overflow.
CALL SERVICE 201	68000 microprocessor diagnostics failure.
CALL SERVICE 202	Tram module ROM checksum error during start-up.
CALL SERVICE 203	Tram module ROM checksum error during operation.
CALL SERVICE 204	Tram module RAM read/write test failure after hot start.
CALL SERVICE 205	Tram module RAM read/write test failure after cold start.
CALL SERVICE 206	Tram module RAM read/write test failure during operation.
CALL SERVICE 208	Tram module RAM battery voltage low. (Replace battery BT1 on the module processor PCB)
EVALUATION ONLY	Tram module software is an unreleased version.
LOW BATTERY	Battery capacity is under 20%.
BATTERY POWERED	The Tram module is running on battery power.
BATTERY FAIL	Smart-pac battery pack failure. This error is usually caused by one of these conditions: Battery pack cell reversal detected Battery pack cell over-temperature detected during charging Battery pack voltage is less than 10 volts Smart-pac battery backpack lost communication with batteries. (Charge the Smart-pac battery pack in a Smart-pac charger.)

Theory of Operation

DAS Module

Each Tram module contains a DAS (data acquisition) module that collects patient data for those parameters that require their electrodes, transducers, and sensors to be isolated from ground for the safety of the patient. These parameters include ECG, pressure, and temperature or cardiac output. The DAS module sends the patient data to the module processor PCB and any other devices on the Tram-net network that require real-time patient data. The DAS module also includes some of the NPB circuitry.

The DAS module contains two circuit boards:

- the isolated power supply PCB, and
- the acquisition processor PCB.

Isolated Power Supply PCB

The isolated power supply PCB provides the acquisition processor PCB with power. Since the acquisition processor PCB has several direct connections with patient electrodes, transducers, etc., the power it uses must be isolated from ground to protect the patient from potentially hazardous current leakage during defibrillation and electrosurgery. As a result, every voltage produced by this PCB is isolated from earth ground. The isolated power supply PCB also passes signals via optocouples between the acquisition processor PCB and the module processor PCB.

Acquisition Processor PCB

The acquisition processor PCB performs the data acquisition functions for the isolated inputs of the Tram module. This includes:

- conditioning all ECG, invasive blood pressure, temperature, and cardiac output signals from electrodes, transducers, sensors, and probes on the patient,
- converting those signals from analog signals to digital data, and
- sending the digital data across the Tram-net to the module processor PCB for further processing.

Power Supply PCB

The power supply PCB performs all power conversions in the Tram module and supplies all other PCBs with the correct voltage levels. The exception to this is the acquisition processor PCB, which is powered by the isolated power supply PCB. The power supply PCB also serves as a path for signals between the module processor PCB and the backplane.

Non-Isolated Input PCB

The non-isolated input PCB is a passive circuit board that passes signals between the module processor PCB and the connectors for the transport display, defib sync connectors, and the power LED.

Fan PCB

The fan PCB regulates the power going to the fan. It also serves as a signal path between the module processor PCB and the NBP valve assembly.

NBP Valve Assembly

The NBP valve assembly contains the pressure release valves that regulates the air pressure in the non-invasive blood pressure cuff.

NBP PCB

This PCB interfaces the pump and solenoid valves in the noninvasive blood pressure assembly with the module processor PCB. This includes buffering pump and solenoid control signals from the module processor PCB, and returning NBP status information to the module processor PCB. Note that all signals between the NBP PCB and the module processor PCB travel across the fan PCB.

Pulse Oximetry PCB

The pulse oximetry PCB acquires arterial oxygen saturation and peripheral pulse rate data using the SpO_2 probe.

Module Processor PCB

The module processor PCB performs most of the data processing in the Tram module. It contains two microprocessors and the support hardware necessary to run them. It collects patient data from the acquisition processor and pulse oximetry pcb assemblies, processes that data, and formats the various monitors or transport display. The data then passes through the power supply PCB on its way to a monitor, or through the non-isolated input PCB on its way to a transport display.

The module processor PCB is a dual processor design consisting of a main microprocessor U3 and communication controller U48. Both processors operate at a frequency of 14.7456-MHz. The dual processor approach frees the main microprocessor from performing low level tasks such as A/D converter control and UART servicing, allowing the available main microprocessor time to be used for digital filtering, arrhythmia analysis, and other algorithmic processing. Communications, analog outputs, and most other I/O tasks are handled by the communication controller. Patient waveform data is acquired by the acquisition processor PCB which contains its own processor.

Operating code for the module is stored in electrically erasable flash EPROM memory U16 and U17 and downloaded at each power- up from the main microprocessor to the other processors in the module. Code may be updated electrically via communication with a PC directly to the front connector.

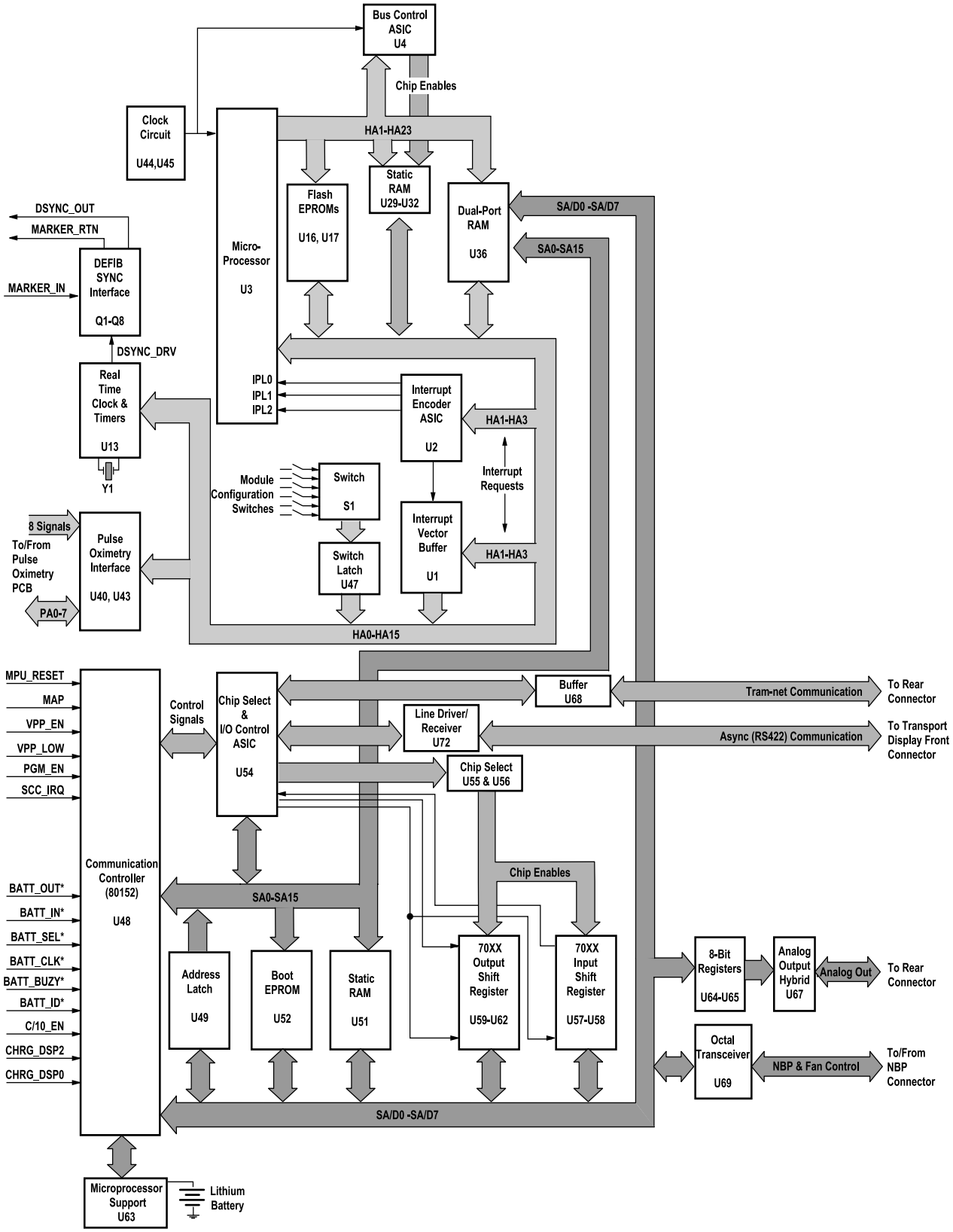
Main Processor

The main microprocessor U3 functions as the host CPU. It controls and coordinates the activities of the other processors in the module. The main microprocessor accesses fairly large amounts of program and data storage memory (for an embedded system). On power up, it downloads operating code to both the communication controller (U48) and the acquisition processor on the acquisition processor PCB via an internal synchronous serial link. Communication with the communication controller is handled by dual-port RAM U36 which provides asynchronous access to the shared static RAM array U29-U32, except for the case in which both processors attempt to access the same address and one is performing a write operation.

Communication Controller

An 8-bit communication controller U48 functions as the serial communications and I/O processor. The communication controller retains the instruction set and on-chip peripherals timer/counters, UART, I/O ports, etc. In addition, it features a multi-protocol communication controller called the “Global Serial Channel,” two channels of DMA, and three more general purpose I/O ports (for a total of six ports).

Block diagram for the module processor PCB



DEFIB SYNC Interface

The DEFIB SYNC interface detects a QRS and outputs a trigger pulse on pin 1of the 7-pin circular connector labeled **DEFIB SYNC**. A defibrillator returns the same pulse on pin 2 if it is powered up and **SYNC MODE** is selected. The monitor then displays a marker pulse on the screen. Both signals are referenced to pin 4 (DGND). The defibrillator fires when the **SHOCK** key(s) are pressed and the sync pulse arrives at the **TRIGGER IN** input.

SYNC MODE can be selected on the defibrillator only if it is connected to the Tram module and both units are powered up. The Tram **SYNC OUT** is open circuit when not powered to allow the defibrillator to detect the power OFF condition.

For your notes

7 Parts Lists and Drawings

For your notes

Ordering Parts

The parts lists and assembly drawings in this chapter supply enough detail for you to order parts for the assemblies considered field serviceable. If you require additional information, schematics, or troubleshooting assistance, contact Tech Support.

To order parts, contact Service Parts at the address or telephone number listed on the "How to Reach Us...," page found in the front of this manual.

Replaceable Parts

The table below lists replaceable parts that can be ordered. The item number references the views on the following pages.

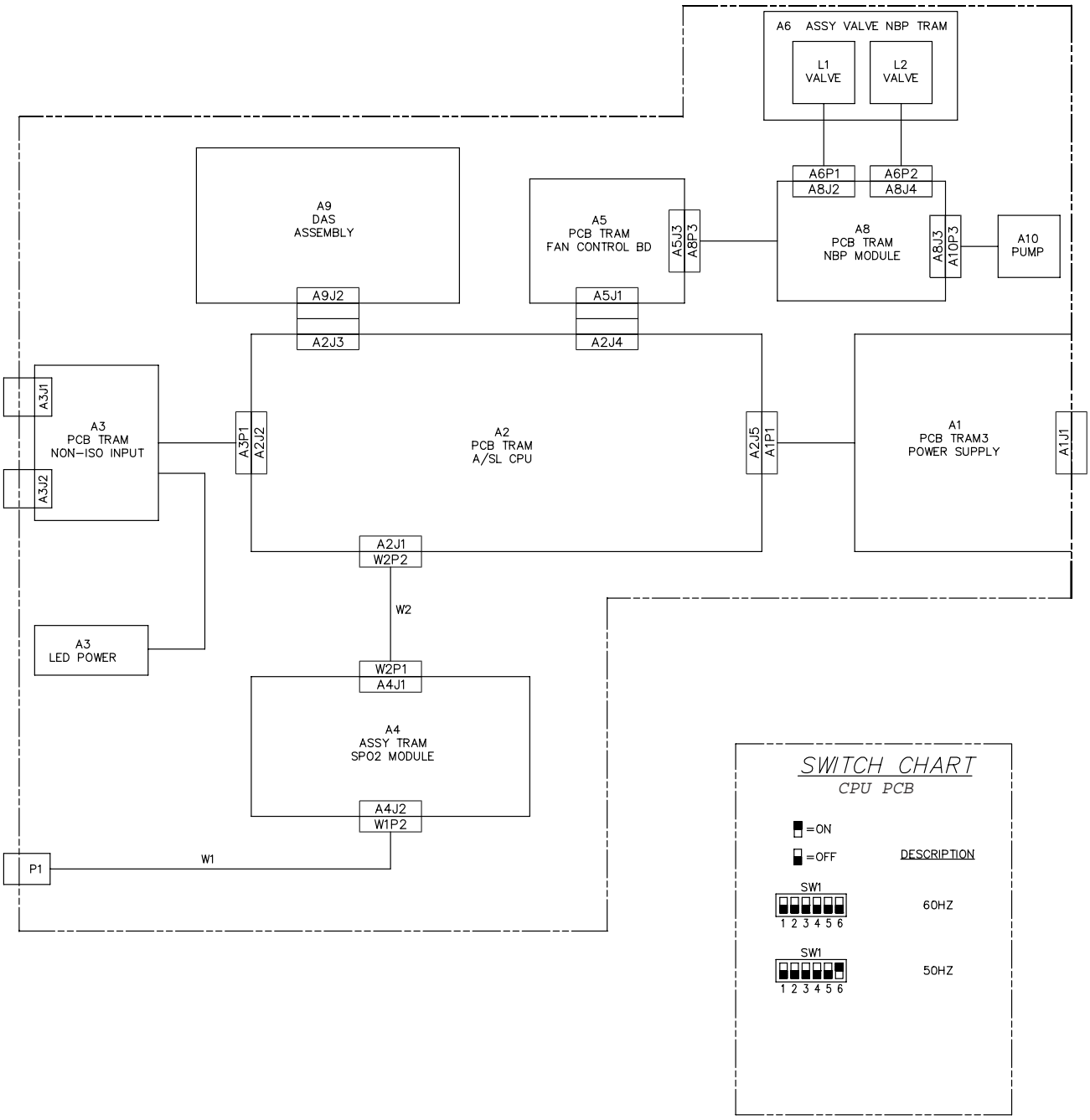
Item #	Item Number	Item Description	451	451N5	451M	451N5	851	851N5	851M
3	401309-102	PCB, Power Supply	X	X	X	X	X	X	X
4	2005558-001	PCB, Non-iso Input	X	X	X	X	X	X	X
15	403549-002	ASSY, PCB Fan Control Board	X	X	X	X	X	X	X
35	417121-002	ASSY, DAS Module TRAM 451 Series	X	X	X	X			
	417123-001	ASSY, DAS Module TRAM 851 Series					X	X	X
39	414409-001	ASSY, SP02 Module	X				X		
	414409-002	ASSY, Nellcor SPO2		X					
	414409-004	ASSY, Masimo SPO2 Module			X				X
	414409-005	ASSY, Nellcor OxiMax SPO2				X		X	
51	800210-006 (-005 is compatible)	PCB, CPU	X	X	X	X	X	X	X
*	408199-002	ASSY, NIBP Pump	X	X	X		X	X	X
	2006859-001	KIT, Tram SPO2 Labels	X	X	X	X	X	X	X
	2006461-001	KIT, Tram 451 Labels, all languages	X						
	2006462-001	KIT, Tram 451N5 Labels, all languages		X					
	2006463-001	KIT, Tram 451M Labels, all languages			X				
	2006464-001	KIT, Tram 851Labels, all languages					X		
	2006465-001	KIT, Tram 851N5 Labels, all languages						X	
	2006466-001	KIT, Tram 851M Labels, all languages							X

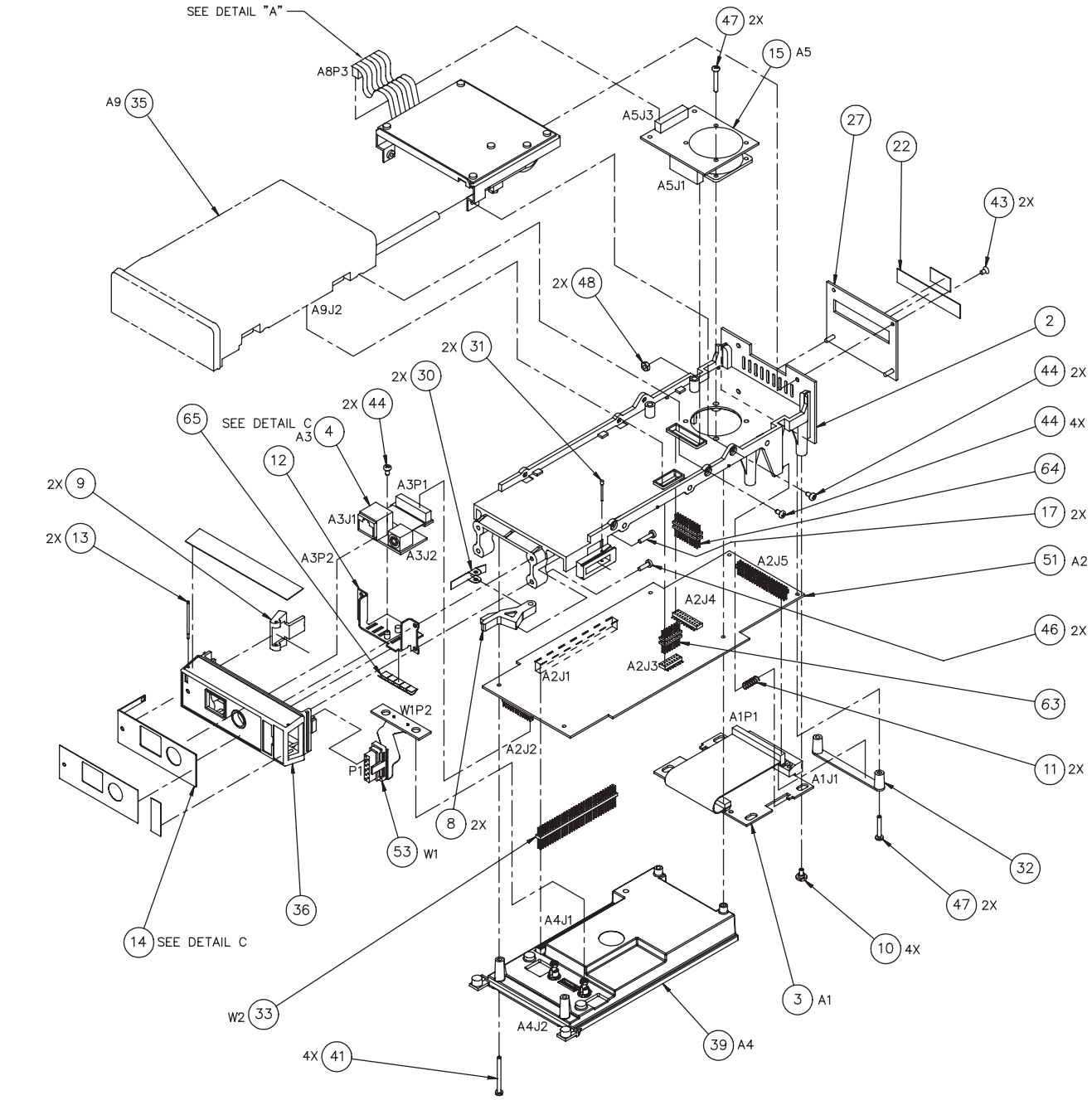
*See detail A of assembly drawing.

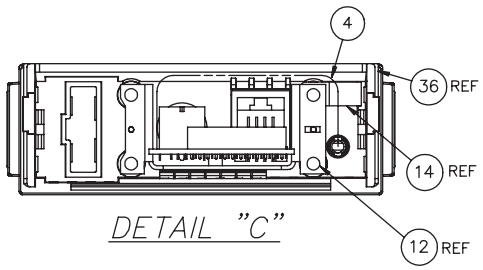
Tram Module Assembly 2006171-00X

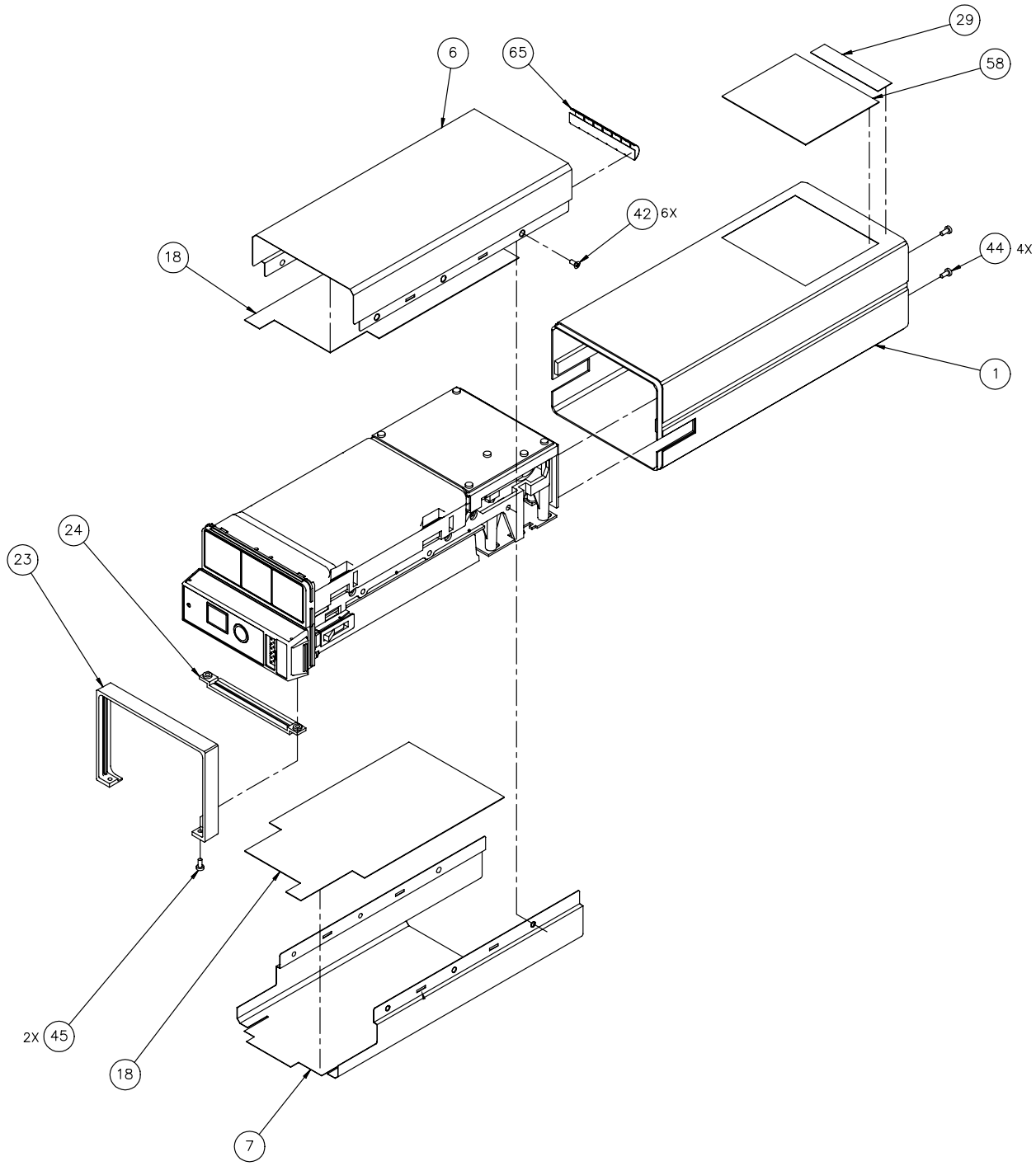
Find Num	Item Number	Item Description	Ref Des	Qty
1	400895-001	TOP COVER TRAM III		0
2	400982-001	FRAME TRAM III		0
3	401309-102	PCB TRAM POWER SUPPLY	A1	1
4	2005558-001	PCB NON-ISO INPUT TRAM 2001	A3	1
5		TUBING SILICONE 1/8ID X 1/4OD X .8L		2
6	401679-001	SHIELD TOP TRAM III		1
7	401679-002	BOTTOM SHIELD TRAM III		1
8	401682-001	LATCH TRAM		2
9	402106-001	LATCH BUTTON TRAM		2
10	402214-001	SHOULDER SCREW TRAM III PSU		4
11	402315-001	COMPRESSION SPRING TRAM III		2
12	402317-001	GROUND PLATE TRAM III		1
13	402806-001	PIN LATCH TRAM III		2
14	2006257-001	SHLD SPO2/LED TRAM 2001		1
15	403549-002	ASSY PCB TRAM FAN CONTROL BD	A5	1
17	404069-001	SCREW BDGH 4-40X.875 PHILLIPS		2
18	404188-001	INSULATOR BOTTOM SHIELD		2
21	404296-001	BRACKET NIBP TRAM		1
22		LABEL PRODUCT/SERIAL		1
23	404620-001	TRIM BEZEL TRAM		1
24	404621-001	TRIM BEZEL MOUNTING STRAP		1
25	418437-001	CHECK VALVE 1/8IN NIBP		1
26	404679-001	FILTER IN-LINE 1/8ID 43 MICRON		1
27	404680-002	GROUND PLATE TRAM NIBP		1
28	404749-001	GROMMET .25 DIA 1/8H 1/16 PNL		5
30	406019-001	LATCH SPRING TRAM		2
31	406037-001	LATCH PIN TRAM		2
32	406254-001	RETENTION BRACKET CPU		0

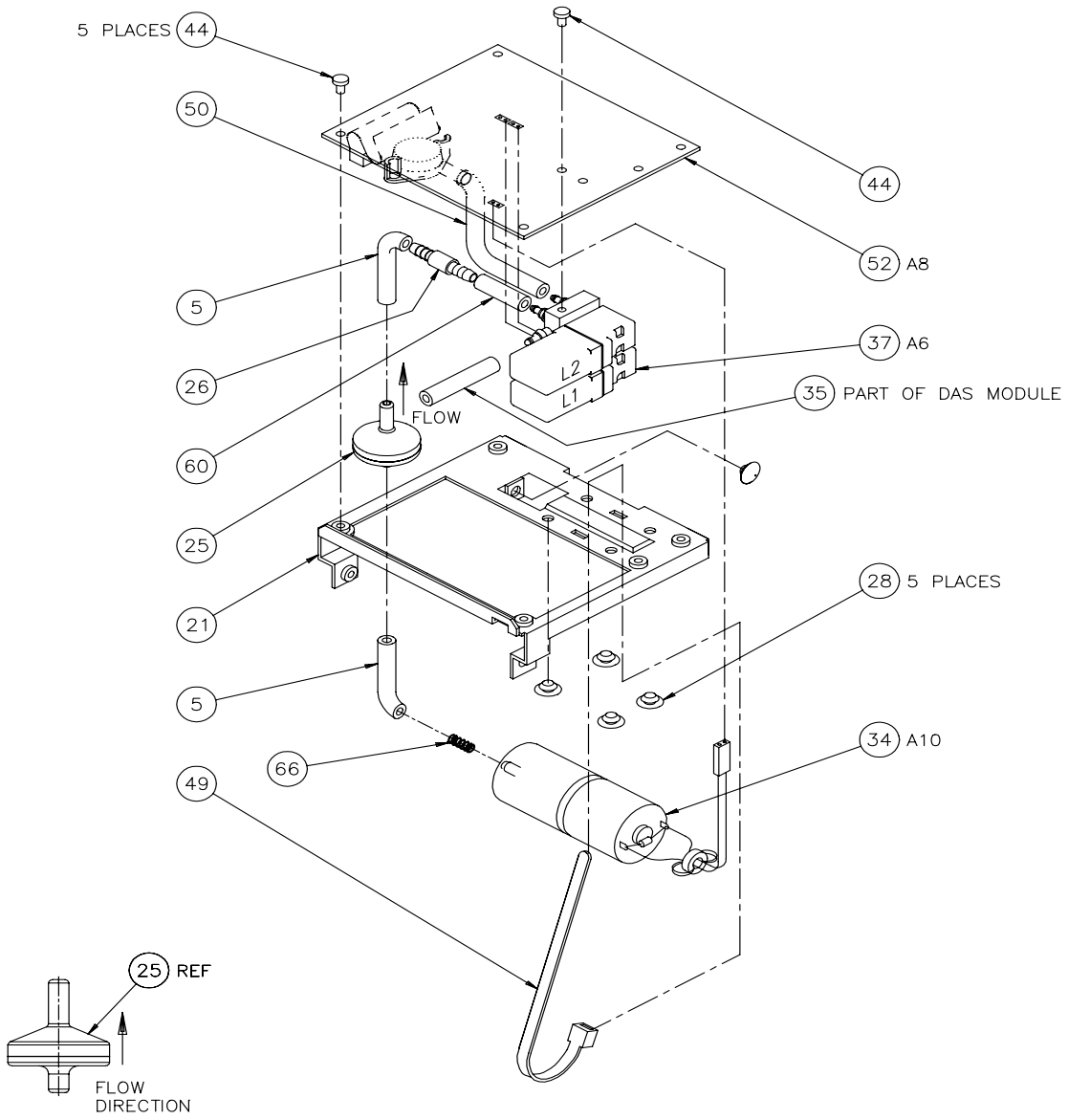
Find Num	Item Number	Item Description	Ref Des	Qty
33	407452-002	CONN HDR 64P DUAL R .1CTR .73H	W2	1
34	408169-002	ASSY PUMP NBP W/FERRITE,TRAM	A10	1
36	412659-003	BEZEL FRONT TRAM 2001		1
37	416153-001	ASSY VALVE/MANIFOLD TRAM	A6	1
41		SCREW PH 4-40X 1 1/4L,		4
42		SCREW 100FLH 4-40X3/16		6
43		SCREW 100FLH 4-40X3/8		2
44		SCREW BDGH 4-40 X .188L		18
45		SCREW BDGH 4-40X3/8,		2
46		SCREW BDGH 4-40 X .62LONG,		2
47		SCREW BDGH 4-40X.75		4
48		NUT,ESNA,4-40,		2
49		TIE WRAP 8.00LG X .187W		1
50		TUBING SILICONE 1/8ID X 1/4OD X 2.0L		1
51	800210-006	PCB TRAM A CPU	A2	1
52	800316-002	PCB TRAM NBP MODULE	A8	1
53	 800892-001 2005010-001 2006123-001 2025730-001	FLEX ASSY TRAM SPO2 451, 851 451N5, 851N5 451M, 851M Nellcor MP514	W1	1
60		TUBING SILICONE 1/8ID X 1/4OD X 4.3L		1
63	412062-004	PCB SPACER .025SQ .240 2X7P		1
64	412062-005	PCB SPACER .025SQ .260 2X11P		1
65		GASKET SPRING EMI 7 FINGER 1.3L		2
66	404855-003	SPRING COMPRESSION .120 X .31		1


A6 ASSY VALVE NBP TRAM
L1 VALVE
L2 VALVE
A6P1
A8J2
A6P2
A8J4
A9 DAS ASSEMBLY
A5 PCB TRAM FAN CONTROL BD
A5J3
A8P3
A8 PCB TRAM NBP MODULE
A8J3
A10P3
A10 PUMP
A9J2
A2J3
A5J1
A2J4
A3J1
A3 PCB TRAM NON-ISO INPUT
A3J2
A3P1
A2J2
A2 PCB TRAM A/SL CPU
A2J5
A1P1
A1 PCB TRAM3 POWER SUPPLY
A1J1
A2J1
W2P2
W2
A3 LED POWER
W2P1
A4J1
A4 ASSY TRAM SPO2 MODULE
A4J2
W1P2
P1
W1
SWITCH CHART
CPU PCB
=ON
=OFF
DESCRIPTION
SW1
1 2 3 4 5 6
60HZ
SW1
1 2 3 4 5 6
50HZ

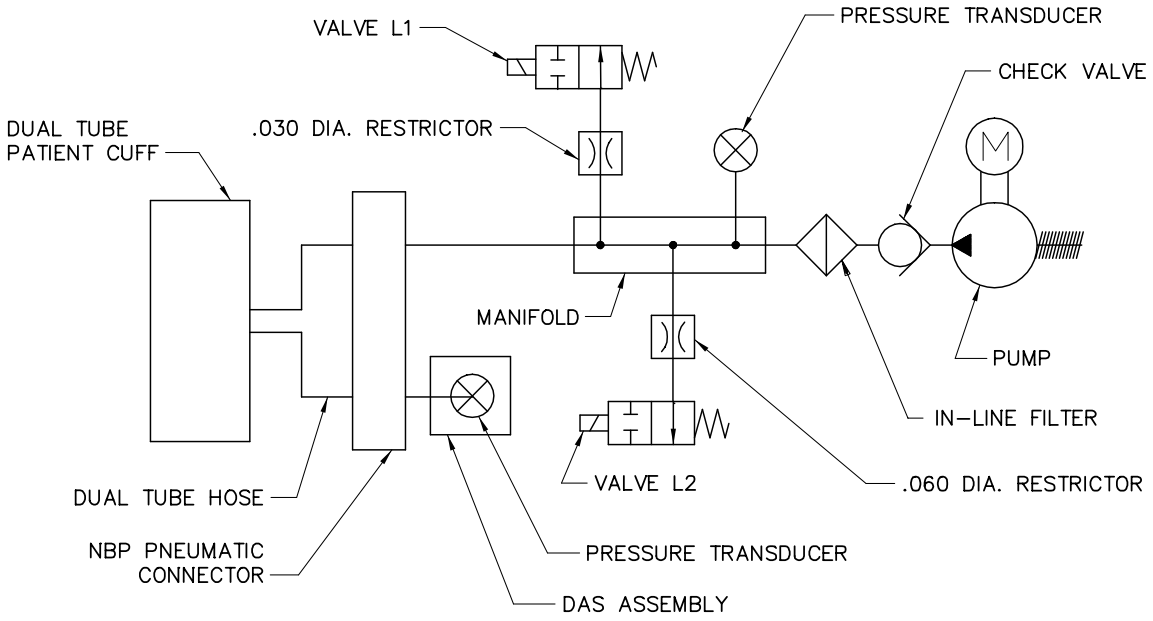

SEE DETAIL "A"
A8P3
A9 35
A9J2
47 2X
15 A5
A5J3
A5J1
27
22
43 2X
2X 48
2
2X 31
2X 30
2X 44
44 2X
44 4X
65
SEE DETAIL C
A3 4
12
64
2X 9
A3P1
A3J1
A3J2
17 2X
2X 13
A3P2
A2J5
51 A2
A2J4
46 2X
A2J1
A2J3
63
W1P2
P1
A2J2
A1P1
11 2X
A1J1
8 2X
53 W1
32
36
47 2X
A4J1
14 SEE DETAIL C
10 4X
3 A1
W2 33
A4J2
39 A4
4X 41


4
36 REF
14 REF
12 REF
DETAIL "C"


29
58
6
65
42 6X
44 4X
18
1
24
23
2X 45
18
7


5 PLACES 44
50
44
52 A8
5
37 A6
26
L2
L1
35 PART OF DAS MODULE
FLOW
60
25
28 5 PLACES
21
5
34 A10
66
49
25 REF
FLOW
DIRECTION

DETAIL "A"



PNEUMATIC SCHEMATIC

A Appendix A – Technical Specifications

For your notes

Technical Specifications

ECG

Standard leads available:	I, II, III, V1 to V6, aVR, aVL, and aVF
Leads analyzed simultaneously:	Twelve (I, II, III, V1 to V6, aVR, aVL, and aVF)
Lead fail:	Identifies failed electrodes and switches to intact one(s)
Lead fail sensing current:	Active electrodes: < 25 nA each, reference electrode: <200 nA
Waveform display aspect ratio:	0.46 sec/mV (amplitude = 12 mm/mV, length = 26 mm/sec) for a 25 mm/sec sweep rate displayed on a 17-inch diagonal display
Input specifications:	
QRS detection range:	±0.5 mV to ±5 mV
Signal width:	40 ms to 120 ms (Q to S)
Heart rate range:	30 to 300 beats per minute
Common mode rejection:	90 dB minimum at 60 Hz
Gain accuracy:	±5% (diagnostic mode)
Linearity deviation:	±5%
Noise:	<30 μV (referred to input)
Output specifications:	
Frequency response:	
Adult mode:	0.05 to 100 Hz
OR mode:	0.05 to 25 Hz
Neonatal mode:	0.5 to 40 Hz
Analog output:	Selectable at 1V/mV
Heart rate:	
Heart rate averaging:	8 Beats
Display update interval:	2 seconds
Response time:	< 6 seconds
Limit alarm delay:	< 10 seconds after limit alarm condition exceeded
Heart rate alarm range:	-1 to 300 beats/minute, high limit > low limit
Arrhythmia analysis:	1 to 100 PVCs/minute
Method:	QRS morphology classification and timing based on single- or multiple-lead analysis
Arrhythmia calls:	Full, lethal only, or no arrhythmia
PVC alarm limit range:	1 to 100 PVCs/minute
ST Segment analysis:	
Measurement description:	ST segment deviation is measured and displayed for all acquired leads
ST display:	Lead label, ST deviation, current complex superimposed over a reference complex, J-point indicator and 15-minute mini-trends are shown for all acquired leads
Measurement point:	Measured at user-selectable measurement points (0, 30, 40, 50, 60, and 80 ms) following the J point
Measurement range:	-12.0 mm to + 12.0 mm

Display resolution:	0.1 mm
ST measurement averaging:	16 beats
ST alarm limits:	± 12 mm, high limit > low limit, for any event within a lead group (inferior, lateral or anterior) that exceeds the alarm limit for that group
Pacemaker detection/rejection:	
Input voltage range	±2 mV to ±700 mV
Input pulse width	0.1 ms to 2 ms
Rise time	10 μs to 100 μs
Over/under shoot	2 mV (maximum)
Baseline drift	<0.5 V with a ±700 mV, 2 ms pacemaker pulse applied
Lead fail:	Identifies failed lead
Detection/rejection mode:	'Pace 1' or 'Pace 2' pacemaker artifact rejection or 'Off'.
Pacemaker alarms:	none specific to pacemaker

Respiration

Respiration rate range:	1 to 200 breaths/minute
Impedance range:	100 to 1000 Ohms at 52.6 KHz
Detection sensitivity range:	0.4 to 10 Ohms impedance variation
Respiration rate alarm range:	1 to 200 breaths/minute
Apnea alarm range:	3 to 30 seconds

Temperature

Number of channels:	2
Input specifications:	
Probe type:	YSI Series 400 or 700 (determined by input cable)
Temperature range:	0° C to 45° C (32° F to 113° F)
Resolution:	±0.02° C (internal)
Output specifications:	
Parameters displayed:	T1, T2
Error:	(independent of source) ±0.1° C for YSI series 400 probes ±0.3° C for YSI series 700 probes
Alarms:	User-selectable upper and lower limits for T1, T2

Invasive Blood Pressure (Tram 451, 451M , 451N, 451N5, and 851N5 only)

Number of channels:	3/4* *With Y-adapter cable
Transducer sites, site name and displayed values:	arterial (ART) - systolic, diastolic, mean and rate femoral (FEM) - systolic, diastolic, mean and rate pulmonary artery (PA) - systolic, diastolic and mean central venous pressure (CVP) - mean left atrial (LA) - mean right atrial (RA) - mean intracranial pressure (ICP) - mean umbilical arterial (UAC) - systolic, diastolic, mean and rate umbilical venous (UVC) - mean special pressure (SP) - mean
Transducer requirements:	
Excitation voltage:	±2.5 V dc ±0.1%
Transducer output:	50 μV/V/cm Hg
Input specifications:	
Range:	–25 mmHg to 349 mmHg
Offset:	±150 mmHg
Output specifications:	
Frequency response:	dc to 40 Hz (+0/-3 dB)
Zero balance range:	±150 mmHg
Zero balance accuracy:	±1 mmHg
Accuracy:	±2% or ±1 mmHg, whichever is greater (exclusive of transducer)
Displayed frequency response:	0 to 12 Hz or 0 to 40 Hz (-3dB) user-selectable
Display scale selections:	0-30, 0-40, 0-60, 0-100, 0-160, 0-200, 0-300 mmHg
Analog output:	1 V / 100 mmHg
Alarms:	User selectable upper and lower limits for systolic, diastolic, and mean pressures; range -99 to 350 mmHg

Noninvasive Blood Pressure

Measurement technique:	Oscillometric
Displayed parameters:	Systolic, diastolic, and mean pressures, pulse rate, time of last measurement
Measurement modes:	Manual, auto, and stat
Heart rate detection:	30 to 200 beats per minute
Total cycle time:	20 to 40 seconds typical (dependent on heart rate and motion artifact)
Systolic pressure range:	
Adult:	30 to 275 mmHg
Pediatric:	30 to 240 mmHg
Neonatal:	30 to 135 mmHg
Diastolic pressure range:	
Adult:	10 to 220 mmHg
Pediatric:	10 to 200 mmHg
Neonatal:	10 to 110 mmHg
Mean pressure range:	
Adult:	20 to 260 mmHg
Pediatric:	20 to 235 mmHg
Neonatal:	20 to 125 mmHg
Cuff pressure range:	
Adult:	0 to 300 mmHg
Pediatric:	0 to 250 mmHg
Neonatal:	0 to 150 mmHg
Pressure accuracy:	
Static:	±2% or ±3 mmHg, whichever is greater
Clinical:	±5 mmHg average error 8 mmHg standard deviation
Automatic cycle times:	0 to 24 hours (may be limited by host)
Auto zero:	Zero pressure reference prior to each cuff inflation
Tubing length:	12 feet adult, 8 feet neonatal
Automatic cuff deflation:	Cycle time exceeding 3 minutes (90 seconds neonatal), power off, or cuff pressure exceeds 294 mmHg (± 6 mmHg) for adult, 250 mmHg (± 5 mmHg) for pediatric, or 147 mmHg (± 3 mmHg) for neonatal
Cuff sizes:	
Disposable:	Large adult, adult, small adult, pediatric, child, and neonatal
Reusable:	Adult thigh, large adult, adult, small adult, small adult/child, child, and infant
Alarms:	User-selectable upper and lower limits for systolic, diastolic, and mean pressures

Pulse Oximetry

Parameters monitored:	Arterial oxygen saturation (SpO2) and peripheral pulse rate (PPR)
Probe types:	Tram 451, 851: GE Medical Systems *Information Technologies* Tram 451M, 851M: Masimo SET Tram 451N5, 851N5: Nellcor OxiSmart
Tram 451 and 851 range (GE):	
SpO2:	0 to 100%
PPR:	30 to 300 beats per minute
Tram 451M and 851M range (Masimo):	
SpO2:	30 to 100%
PPR:	25 to 240 beats per minute
Tram 451N5/851N5 range (Nellcor):	
SpO2:	1 to 100%
PPR:	20 to 250 beats per minute
Tram 451 and 851 accuracy (GE):	
90 to 100% SpO2:	±1.5% (of overall range)
80 to 89.9% SpO2:	±2.1%
60 to 79.9% SpO2:	±2.4%
SpO2 < 60%:	unspecified
PPR	±1.7% of current reading (assumes constant pulse rate)
Tram 451M and 851M accuracy (Masimo):	
70 to 100% SpO2:	Adult ±2, Neonatal ±3
69% or below SpO2:	Unspecified
PPR	±3 beats per minute
Tram 451N5/851N5 accuracy (Nellcor):	
Without motion:	
70 to 100% SpO2:	Adult ±2, Neonatal ±3
69% or below SpO2:	Unspecified
PPR	±3 beats per minute
With motion:	
70 to 100% SpO2:	±3
69% or below SpO2:	Unspecified
PPR	±5 beats per minute
Analog output:	Selectable saturation 0 to 100% equivalent 0 to 1V
Alarm limit range:	SpO2: 0 to 105%; PPR: 0 to 350 beats per minute.

Messages sent to host:
GE:Pulse search, Poor signal quality detected, Probe is off patient, Probe or module malfunction
Masimo:Probe or module malfunction, Artifact detected, Probe is off patient, Low quality, Pulse search
Nellcor:Probe is off patient, Low quality, Pulse search

Cardiac Output

Method:	Thermal dilution
Input Specifications:	
Probe type:	In-line or bath probe
Catheter manufacturers:	Abbott, Arrow, Baxter, Ohmeda, or other
Catheter sizes:	
Abbott catheter sizes:	5.5F (75 cm), 7F (85 cm), 7.5F (110 cm), and 8F (110 cm)
Arrow catheter sizes:	5, 6, 7, or 7.5F
Baxter catheter sizes:	5, 6, 7, 7.5 or 8F
Ohmeda catheter sizes:	5, 7, or 7.5F
Other catheter sizes:	Cardiac coefficient entered manually
Injectate volume:	3, 5, or 10 cc
Output Specifications:	
Parameters Displayed:	Cardiac output, blood temperature, injectate temperature, real-time cardiac output waveform, last average CO
Range:	
Cardiac output:	0.2 - 15 liters per minute
Blood temperature:	30 - 42°C
Injectate temperature:	0 - 30°C
Accuracy:	
Cardiac output:	±5% (liters of blood/min)
Blood temperature:	±0.2°C
Injectate temperature:	±0.3°C
Frequency response:	dc to 15 Hz ±2 Hz
Cardiac output review:	Accept / reject individual measurements and store average

Environmental Specifications

Power requirements:	16.5 VDC
Power consumption:	10 Watts (nominal, module alone)
Cooling:	Forced air
Heat dissipation:	34 Btu/hr
Operating temperature:	10° C to 35° C (50° F to 95° F)
Operating humidity:	40% to 95% (noncondensing)
Storage temperature:	-10° C to 50° C (14° F to 122° F)
Storage humidity:	0% to 95% (noncondensing)

Physical Specifications	
Height:	8.1 cm (3.2 in)
Width:	11.4 cm (4.5 in)
Depth:	29.5 cm (11.6 in)
Weight:	2.1 kg (4.7 lb)

Certification	UL 60601-1 Classified UL Classified for CAN/CSA C22.2 No. 601.1 EN 60601-1 Certified EN 60601-1-2 EN 60601-1-4 EN 60601-2-27 EN 60601-2-30 EN 60601-2-34 EN 60601-2-49 EN 12470-4 CE Marked to Medical Devices Directive 93/42/EEC

Classifications	
Type of protection against electrical shock	**Not applicable**—refer to monitoring system
Degree of protection against electrical shock	**Type B Equipment**
Degree of protection against harmful ingress of water	**Ordinary Equipment** (enclosed equipment without protection against ingress of water)
Degree of safety of application in the presence of a flammable anesthetic mixture with air or with oxygen or nitrous oxide	**Equipment not suitable** for use in the presence of a flammable anesthetic mixture with air or with oxygen or nitrous oxide
Method(s) of sterilization or disinfection recommended by the manufacturer	**Not applicable**
Mode of operation	**Continuous operation**

For your notes

B Appendix B – Electromagnetic Compatibility

Electromagnetic Compatibility (EMC)

Changes or modifications to this system not expressly approved by GE Medical Systems can cause EMC issues with this or other equipment. This system is designed and tested to comply with applicable regulation regarding EMC and must be installed and put into service according to the EMC information stated in this supplement.

WARNING
Use of portable phones or other radio frequency (RF) emitting equipment near the system may cause unexpected or adverse operation.

WARNING
The equipment or system should not be used adjacent to, or stacked with, other equipment. If adjacent or stacked use is necessary, the equipment or system should be tested to verify normal operation in the configuration in which it is being used.

Guidance and Manufacturer's Declaration – Electromagnetic Emissions

The TRAM Modules are intended for use in the electromagnetic environment specified below. It is the responsibility of the customer or user to assure that the TRAM Modules are used in such an environment.

Emissions Test	Compliance	Electromagnetic Environment – Guidance
RF Emissions EN 55011	Group 1	The equipment uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF Emissions EN 55011	Class A	The equipment is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic Emissions EN 61000-3-2	Not Applicable	
Voltage Fluctuations/ Flicker Emissions EN 61000-3-3	Not Applicable	

Guidance and Manufacturer's Declaration – Electromagnetic Immunity

The TRAM Modules are intended for use in the electromagnetic environment specified below. It is the responsibility of the customer or user to assure that the TRAM Modules are used in such an environment.

Immunity Test	EN 60601 Test Level	Compliance Level	Electromagnetic Environment – Guidance
Electrostatic Discharge (ESD) EN 61000-4-2	± 6 kV contact ± 8 kV air	± 6 kV contact ± 8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical Fast Transient/Burst EN 61000-4-4	± 2 kV for power supply lines ±1 kV for input/output lines	± 2 kV for power supply lines ±1 kV for input/output lines	Mains power should be that of a typical commercial or hospital environment.
Surge EN 61000-4-5	± 1 kV differential mode ± 2 kV common mode	± 1 kV differential mode ± 2 kV common mode	Mains power should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines EN 61000-4-11	<5% U_t (>95% dip in U_t) for 0.5 cycles <40% U_t (>60% dip in U_t) for 5 cycles <70% U_t (>30% dip in U_t) for 25 cycles <5% U_t (>95% dip in U_t) for 5 s	N/A	No AC Input
Power Frequency (50/60 Hz) Magnetic Field EN 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.

NOTE:
U_t is the AC mains voltage prior to application of the test level.

Guidance and Manufacturer's Declaration – Electromagnetic Immunity

The TRAM Modules are intended for use in the electromagnetic environment specified below. It is the responsibility of the customer or user to assure that the TRAM Modules are used in such an environment.

Immunity Test	EN 60601 Test Level	Compliance Level	Electromagnetic Environment – Guidance
			Portable and mobile RF communications equipment should not be used closer to any part of the equipment, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. **Recommended separation distance**
Conducted RF EN 61000-4-6	3 Vrms 150 KHz to 80 MHz	3 V rms	$d = 1.2\sqrt{P}$
Radiated RF EN 61000-4-3	3 V/m 80 MHz to 2.5 GHz	3 V/m	$d = 1.2\sqrt{P}$ 80 MHz to 800 MHz $d = 2.3\sqrt{P}$ 800 MHz to 2.5 GHz where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer, and d is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey[a], should be less than the compliance level in each frequency range[b]. Interference may occur in the vicinity of equipment marked with the following symbol:

Note 1: At 80 MHz and 800 MHz, the higher frequency range applies.

Note 2: These guidelines may not apply in all situations. Electromagnetic propagation is affected by reflection from structures, objects, and people.

[a]Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radio, AM and FM radio broadcast, and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the equipment is used exceeds the applicable RF compliance level above, the equipment should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the equipment.

[b]Over the frequency range 150 KHz to 80 MHz, field strengths should be less than 3 V/m.

Recommended Separation Distances

The table below provides the recommended separation distances (in meters) between portable and mobile RF communications equipment and the TRAM Modules.

The TRAM Modules are intended for use in the electromagnetic environment on which radiated RF disturbances are controlled. The customer or the user of the TRAM Modules can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the TRAM Modules as recommended below, according to the maximum output power of the communications equipment.

	Separation Distance in Meters (m) According to Frequency of Transmitter		
Rated Maximum Output Power of Transmitter in Watts	**150 kHz to 80 MHz [a]** $d = 1.2\sqrt{P}$	**80 MHz to 800 MHz [a]** $d = 1.2\sqrt{P}$	**800 MHz to 2.5 GHz [a]** $d = 2.3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23
[a]At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.			

For transmitters rated at a maximum output power not listed above, the recommended separation distance [*d*] in meters (m) can be estimated using the equitation applicable to the frequency of the transmitter, where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE:

These guidelines may not apply in all instances. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

Compliant Cables and Accessories

WARNING
The use of accessories, transducers and cables other than those specified may result in increased emissions or decreased immunity performance of the equipment or system.

The table below lists cables, transducers, and other applicable accessories with which GE Medical Systems claims EMC compliance.

NOTE: Any supplied accessories that do not affect EMC compliance are not included.

Category	Description	Maximum Length
ECG Cables		
	Multi-Link 12-Ld ECG Standard Cable	3.6 m / 12 ft
	Multi-Link 5-Ld ECG Standard Cable	6 m / 20 ft
	Multi-Link 3-Ld ECG Neonatal Cable	3.6 m / 12 ft
	Multi-Link 3-Ld ECG Cable w/Grabber	3.6 m / 12 ft
	Multi-Link 5-Ld ECG ESU	3.6 m / 12 ft
	Multi-Link, 3/5-Ld ECG Cable	3.6 m / 12 ft
	Multi-Link 3-Ld Neonatal ECG Cable	3.6 m / 12 ft
	Multi-Link 3-Ld ECG Cable w/Grabber	3.6 m / 12 ft
	Multi-Link 6-Ld ECG Cable	3.6 m / 12 ft
	Multi-Link 12 SL ECG Cable	3.6 m / 12 ft
	Multi-Link 3/5/6 Adapter	N/A
	Multi-Link to 300-Series 3-Ld Trunk Cable	3 m / 10 ft
	Multi-Link to 300-Series 5-Ld Trunk Cable	3 m / 10 ft
ECG Multi-Link Lead wires		
	Multi-Link lead wire Set-Group, 5-Ld, Grabber	130 cm / 51 in
	Multi-Link lead wire Set-Group, 3-Ld, Grabber	130 cm / 51 in
	Multi-Link lead wire set, 5-Ld, Grabber	130 cm / 51 in
	Multi-Link lead wire set, 5-Ld, Grabber V2-V6	130 cm / 51 in
	Multi-Link lead wire set, 3-Ld, MiniGrab AHA Ld I	74 cm / 29 in
	Multi-Link lead wire set, 3-Ld, MiniGrab IEC Ld I	74 cm / 29 in

Category	Description	Maximum Length
	Multi-Link lead wire set, 3-Ld, Adult Graber AHA Ld II	74 cm / 29 in
	Multi-Link lead wire set, 3-Ld, Adult Grabber IEC Ld II	74 cm / 29 in
	Multi-Link Ldwr Set-Group, 5-Ld, Snap	130 cm / 51 in
	Multi-Link Ldwr Set-Group, 3-Ld, Snap	130 cm / 51 in
	Multi-Link Ldwr Set, Mini-Clip/DIN, Neonatal	60 cm / 24 in
	Multi-Link Ldwr Set, 5-Ld, Snap	130 cm / 51 in
	Multi-Link Ldwr Set, Radiotranslucent Grabber	1.6 m / 60 in
	Multi-Link Ldwr Set, 6-Ld, Snap	130 cm / 51 in
	Multi-Link Ldwr Set, Individual, Grabber	130 cm / 51 in
	Multi-Link Ldwr Set, Individual, Snap	130 cm / 51 in
	Multi-Link Ldwr Set, Individual, Grabber, V2-V6	130 cm / 51 in
	300-Series 3-Ld Set w/clips	75 cm / 30 in
	300-Series 3-Ld Set w/clips	1.5 m / 60 in
	300-Series 3-Ld Set w/snaps	75 cm / 30 in
	300-Series 5-Ld Set w/clips	125 cm / 49 in
	300-Series 5-Ld Set w/clips	1.5 m / 60 in
	300-Series 5-Ld Set w/snaps	125 cm / 49 in
	300-Series replacement clip lead	125 cm / 49 in
	300-Series replacement clip lead	1.5 m / 60 in
	300-Series replacement clip lead	75 cm / 30 in
	300-Series replacement snap lead	125 cm / 49 in
Invasive BP Cables and Transducers		
	Utah Transducer Adapter Cable	3.6 m / 12 ft

Category	Description	Maximum Length
	Spectramed Transducer Adapter Cable	3.6 m / 12 ft
	Dual BP adapter	30 cm / 12 in
	Utah Transducer Adapter Cable	3.6 m / 12 ft
	Abbott Transpac-III Adapter Cable	3.6 m / 12 ft
	Abbott Transpac-IV Adapter Cable	3.6 m / 12 ft
	Edwards Truwave Adapter Cable	3.6 m / 12 ft
	Spectramed Transducer Adapter Cable	3.6 m / 12 ft
	Utah Disposable Transducers (DPT, DP2, DP3)	N/A
	Spectramed Transducers (TC-MQ)	N/A
	Abbott Transpac-III Transducers	N/A
	Abbott Transpac-IV Transducers	N/A
	Edwards Truwave Transducers (PX)	N/A
Cardiac Output Cables and Probes		
	Cardiac Output Cable	3.6 m / 12 ft
	Cardiac Output Probe	2.4 m / 8 ft
	Cardiac Output Cable	3.6 m / 12 ft
Temperature Cables and Probes		
	Dual Temp Cable	20 cm / 8 in
	Temp Probe Interconnect Cable	3.6 m / 12 ft
	Dual Temp Cable	20 cm / 8 in
Pulse Oximetry Cables and Sensors		
	Nellcor RCAL OxiSmart Interface Cable	3.6 m / 12 ft
	Masimo SET Interface Cable	3.6 m / 12 ft

Category	Description	Maximum Length
	Masimo SET Interface Cable	3.6 m / 12 ft
	Nellcor RCAL Interface Cable	3.6 m / 12 ft
	Nellcor OxiMax Interface Cable	3 m / 10 ft
	Masimo Finger Sensor, Pediatric	N/A
	Masimo Finger Sensor, Adult	N/A
	Masimo Sensor Finger Probe	N/A
Accessories		
	TRAM Display Cable	4.5 m / 15 ft
	Defib Sync Cable	3 m / 10 ft

For your notes

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